PB85-151165

Benefits of Regulating Hazardous Waste Disposal Land Values as an Estimator. Volume 2

Public Interest Economics Center, Washington, DC

Prepared for

Environmental Protection Agency, Washington, DC

Jun 84

U.S. Department of Commerce
National Technical Information Service
NTIS

PB85-151165

The Benefits of Regulating Hazardous Waste Disposal: Land Values as an Estimator

Volume II

by

Zena L. Cook

Allen R. Ferguson

Kenneth J. Adler

Margo J. Vickers

Submitted to

Office of Policy Analysis
U.S. Environmental Protection Agency
Washington, D.C.

by

Public Interest Economics Foundation
1525 New Hampshire Avenue, NW
Washington, D.C. 20036

June 1984

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

This research was funded by the U.S. Environmental Protection Agency under contracts #68-01-5838 and #68-01-6543. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA-230-03-85-003	2.	3. Recipient's Accession No. PB85 151165/AS
4. Title and Subtitle Benefits of Regulating Hazardous Waste Disposal: Land Values as an Estimator, Volume II			5. Report Date June, 1984 6.
7. Author(s) Zena L. Cook, Allen R. Ferguson, Kenneth J. Adler, and Margo J. Vickers			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Public Interest Economics Foundation 1525 New Hampshire Avenue, N.W. Washington, D.C. 20036			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) #68-01-5838, and (G) #68-01-6543
12. Sponsoring Organization Name and Address Economic Analysis Division, PM-220 U.S. Environmental Protection Agency 401 M Street, S.W. Washington, D.C. 20460			13. Type of Report & Period Covered Final 14.

15. Supplementary Notes

Supplements Volume 1

16. Abstract (Limit: 200 words)

Conceptual and empirical examination of whether the social costs imposed by hazardous waste sites are reflected in property values. A hedonic analysis is used, to account for other characteristics of houses that affect their values. Additional data are collected and analyzed for the Pleasant Plains site, which caused the rent gradient tentatively identified in Phase I to disappear. An attempt to identify a hazardous waste site with air pollution and property value data amenable to analysis was unsuccessful. The results of the analysis fail to show that this property values approach can be used to estimate the damages from (or the benefits from more stringent regulation of) hazardous waste disposal.

17. Document Analysis a. Descriptors

a) hazardous waste disposal
hedonic analysis
property values

b. Identifiers/Open-Ended Terms

b) risks from hazardous waste facilities; environmental regulation benefits

c. COSATI Field/Group

18. Availability Statement: No restriction on distribution. Available from National Technical Information Service, Springfield, VA 22161	19. Security Class (This Report) Unclassified	21. No. of Pages 90
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

Acknowledgements

This report completes Work Assignment No. 31 under EPA Contract No. 68-01-6543. It presents the results of Phase II of a study by the Public Interest Economics Foundation, designed to explore whether land values constitute a valid estimator of the benefits of cleaning up hazardous waste sites.

The principal investigator of Phase II was Zena L. Cook, general management was provided by Allen R. Ferguson and research assistance by Margo J. Vickers and Kenneth J. Adler. This report was edited and produced by Vernon W. Palmer II, with the assistance of Marilyn E. Matthews.

The entire project was reviewed by the following: A. Myrick Freeman III, Department of Economics, Bowdoin College; Robert M. Schwab, Department of Economics, University of Maryland; Jon D. Harford, Benefits Staff, Office of Policy Analysis, U.S. Environmental Protection Agency; Robert Mendelsohn, Department of Economics, University of Washington, Seattle; Allen V. Kneese, Resources for the Future, Washington, D.C.; V. Kerry Smith, Department of Economics, University of North Carolina; Steve Beggs, Charles River Associates, Boston; and Al McGartland, Benefits Staff, Office of Policy Analysis, U.S. Environmental Protection Agency. The PIE staff worked with Ann Fisher, the EPA project manager, who was closely involved with Phase II and made valuable suggestions during the course of the undertaking.

Table of Contents

	Page
Preface: The Two Phases	v
PHASE II	
I. Introduction	1
II. The Method	4
A. Model 1	5
B. Model 2	6
C. Models 3 and 4	10
III. Results	12
A. Model 1	12
B. Model 2	21
C. Models 3 and 4	23
IV. Conclusions	25
A. Empirical Findings	25
B. The Study	27
C. The Method	29
D. The Benefits of Regulating Hazardous Waste Sites	33
Appendix A: Search for an Air Site	A-1
Appendix B: Criteria for Site Selection	B-1
Appendix C: Detailed Results of Phase II	C-1
Appendix D: Comments of Reviewers	D-1

Table of Contents (continued)

Page

Tables

1. Distance Gradient After Contamination 13
2. Distance Gradient Before Contamination 13

Figures

1. Distance Gradient After Contamination 14
2. Distance Gradient Before Contamination 15
3. Distance Gradient Before and After Contamination 20

Maps

Map 1: Map of Contamination Zones xii

Preface: The Two Phases

This volume, Volume II, reports on the second phase of a two-phase study. The first phase was documented in "The Benefits of Regulating Hazardous Waste Disposal: Land Values as an Estimator, Volume I." To present the analysis and the results of the overall study, one option was to combine the two phases into a single report. This would have achieved greater integration of the subject matter and would have permitted addressing the suggestions made by a set of outside reviewers of the first phase more fully than has otherwise been possible. Unfortunately, time and budgetary considerations have constrained our choice. As an alternative, Phase I is summarized in this Preface for those not familiar with Volume I; Phase II is described in the main text and then some of the comments and suggestions of reviewers of Phase I are addressed in an appendix to this volume.

The results in Phase II are different from and conflict with those of Phase I. Because the second phase, built on the first, uses a more complete sample and incorporates techniques intended to eliminate deficiencies in the earlier work, the findings of Phase II supercede those of Phase I.

Both phases of this study have been directed toward determining in theoretical terms, with empirical verification, whether changes or differences in real property values constitute a valid and useful measure of the costs imposed by a hazardous waste site on the proximate neighborhoods and, hence, of the welfare gains potentially achievable through regulating the location or characteristics of such sites.

In Phase I the theoretical underpinnings of applying hedonic demand theory to estimating the potential benefits of regulating hazardous waste sites were analyzed. Studies using hedonic techniques to evaluate amenities or disamenities other than hazardous waste sites also were examined. The earlier theoretical and empirical work, summarized in Volume I, suggested that property values might be used successfully as a measure of the extent to which a facility such as a hazardous waste site is a disamenity and, therefore, that it was worthwhile to explore, develop and test a general method of using land values for doing so. Consequently, we proceeded to collect and analyse empirical data on property in the vicinity of hazardous waste sites and to the application of a hedonic model.

The large number of determinants of real estate prices dictates drawing a large, reasonably homogeneous sample. The largest possible reasonably homogeneous sample was obtained by using transactions in developed residential property only, rather than transactions involving all property in the local market. The resulting sample was still smaller than might have been desirable.

It was decided to use transaction price rather than assessed value as the value to be explained. Although using assessed value would increase the observations available for sampling, it is market value that is relevant for analysis. Since assessments of property take place only periodically, they are unlikely to reflect market price accurately.

The general approach chosen for this study and tested in both phases constitutes only one of two plausible approaches. It was beyond the scope of this endeavor to test more than one of them.

The alternative approaches are (1) a broad cross-sectional analysis in which data are aggregated from many sites and (2) an analysis of sites individually. The latter was chosen primarily on grounds of feasibility. The first approach was not considered feasible without large expenditures of resources, because hazardous waste sites and their surrounding populations, which constitute a sample of observations for this approach, are not homogeneous enough to permit aggregation of a small number of sites without losing the degrees of freedom required for empirical analysis. For example, the problems associated with hazardous waste sites such as air pollution, water pollution and negative aesthetic values tend to differ among sites in both magnitude and characteristics. Also, the populations which surround hazardous waste sites tend to have different socioeconomic characteristics and those characteristics are believed to influence the value of disamenities.

The second approach was judged to be feasible because it avoided the aggregation problem of the first. However, some of the usefulness of the method is lost in the second approach because the results of a study of individual sites cannot be generalized readily. Since each site has different characteristics, a study of two, three or even five or six sites cannot produce a universally appropriate formulation of the property value method.

The principal hypothesis of any property values study to measure the impacts of a hazardous waste site or sites is that such a site, being a geographically fixed disamenity, depresses property values in its vicinity. Disamenity effects were defined as any welfare losses experienced, including health costs and negative aesthetic values and the expectation

of incurring such losses. However, it is impossible to measure directly the disamenities associated with such a site. Therefore it was necessary, in Phase I, to develop proxies for the disamenities. Distance from the site was the primary surrogate used; a secondary one was the published identification of areas where ground water was found to be contaminated. (A finding that property values were enhanced by proximity to a hazardous waste site would be consistent with a hypothesis that such a facility is an amenity, for example, in reducing production costs in particular industries.)

To test the effect of proximity to a hazardous waste site, as reflected in either of the proxies, two applications of the general approach were considered and both were used in both phases of the study. The first consists of developing a single cross-sectional equation showing property values as a function of the proxy selected after a site was established or after some incident occurred making obvious to the participants in the local real estate market the consequences of the site's existence. An explosion or the detection of contamination is such an incident. The expected result is a gradient of land values rising as a function of the proxy. The second consisted of creating and comparing two such equations, one before and one after the siting or the conspicuous event. The latter appears superior, where data from both periods are available.

The choice of sites was limited to those which provided enough observations. Because a hazardous waste site is only one of many factors influencing property values in its area, a large number of explanatory variables is required in order to isolate its effect. A large number of

explanatory variables requires a large number of observations to generate the required degrees of freedom. A large sample, in turn, requires choosing a site both in a fairly densely populated area and where the hazard was perceived by the residents for a significant period.

These criteria turned out to be restrictive but not prohibitive in the choice of sites in Phase I. While there were relatively few sites that fulfilled these as well as other criteria, there were some that did. After a fairly exhaustive survey of the Superfund list for sites suitable for empirical testing of our model, two sites were chosen--one in Pleasant Plains, New Jersey, and the other in Andover, Minnesota.[1] An empirical analysis of each site was conducted. A model was developed for each site depending on its characteristics and the characteristics of its environs.

In Andover, Minnesota, a single cross-sectional equation was developed in Phase I to test a sample of post contamination transactions using distance as the proxy for the disamenity of the hazardous waste site.

In the Pleasant Plains area, two samples were used in both phases: a sample of transactions which occurred before there was widespread public concern about the site, i.e., before 1974, and a sample of transactions which occurred after the public had become aware of the incident, i.e., after 1974. (Although dumping took place in 1972, public concern was not expressed until contamination of private wells in the vicinity was discovered in 1974.) An official contamination zone was established in Pleasant Plains. This provided the alternative to distance as a proxy

---

[1]Pleasant Plains is in a subdivision of the town of Toms River; Andover is a suburb of Minneapolis.

for this site. The potential benefits of regulating the Pleasant Plains site were then estimated. This was done using available cost data (which included estimates of clean-up costs) as well as by examining the residual effect of the contamination incident on property values.

The empirical results of Phase I were inconclusive both with respect to the question of whether the sites constituted a disamenity (in spite of the fact that each was chosen because it had a contamination problem) and with respect to the validity and usefulness of the technique. The Pleasant Plains data revealed a weak and inconclusive, positive relationship between distance and property values. The Andover sample revealed no measurable relationship between distance and property values.

Three principal problems were identified in the Pleasant Plains empirical work: the smallness of the sample in some specific parts of the entire area, inability to identify other factors affecting property values and inability to define clearly both the distance and contamination proxies so that they took account of physical factors such as ground water flow, in the case of the distance proxy, and actual exposure in the case of the contamination proxy. The findings of Phase I with respect to the Pleasant Plains hazardous waste site are described in more detail as follows:

- The sample consisting of pre-1974 sales was too small to permit determining property value differences associated with distance from the hazardous waste site before contamination was identified. Further, the absence in both samples (pre- and post-1974 sales) of observations more than 2.5 miles from the site made it impossible to establish whether and, if so, at which distance property values were unaffected by that facility.

- The empirical study showed that if there were any effect, it was a weak one. Consequently, it was difficult to separate the negative property value response to the presence of the hazardous waste site from the positive response attributable to the fact that the dump was situated in an increasingly popular part of the entire real estate market. This latter fact made it difficult to evaluate both distance and contamination as proxies for the effect of the hazardous waste site.
- Examining contamination as the proxy for the effect of the hazardous waste site was problematic also, because the official contamination zones were not reliable and consistent indicators of actual contamination. Since contamination was limited to individual wells, an examination was directed to households which used well water.
- While some property owners within the official contamination zone were ordered to seal their wells and to hook up to a municipal water supply and others to dig their wells deeper, some residents in the official contamination zones were unaffected by local ordinances (see Map 1);[2] In addition, the distribution of the effect of government action was not uniform over the population in the contamination zones.[3]

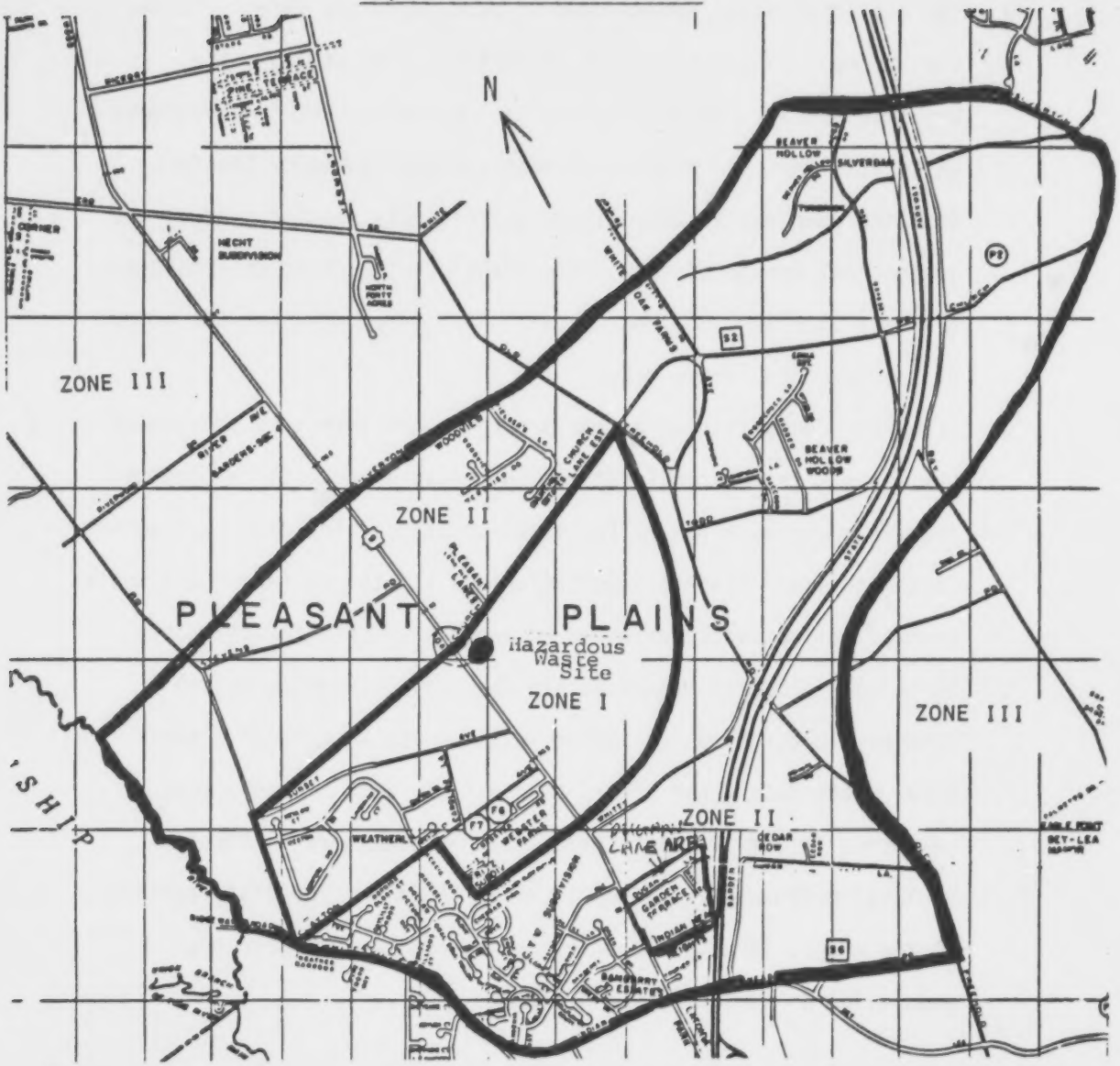
---

[2]There were two contamination zones and two local ordinances. Houses, within roughly one mile of the site, i.e., Zone 1, were ordered to hook up to the municipal water supply and to seal their wells. Houses built after 1974, within roughly two miles, i.e., Zone 2, were ordered to dig their wells deeper. Houses built before 1974 in Zone 2 were, therefore, exempt from both ordinances. Households were compensated for most of the costs they incurred.

[3]Further, since the ordinances did not affect residents outside the two contamination zones, the effect of government action was not uniform over the population in the Toms River/Pleasant Plains area as a whole.

Map 1

Map of Contamination Zones



Key

Zone I Contaminated
Zone II Questionable Area
Zone III - Uncontaminated

New Jersey Department of Environmental Protection, Final Report--Delineation of Extent of Groundwater Contamination, Pleasant Plains Section of Dover Township, Ocean County, New Jersey, December 1974.

- Based on the plausible assumption that residents equidistant from the hazardous waste site should perceive their costs to be the same, distance from the hazardous waste site was defined symmetrically. In reality, for the following reasons, residents in Pleasant Plains are unlikely to behave as predicted: first, because contamination of underground aquifers is the principal problem associated with the Pleasant Plains hazardous waste site and ground water in this region flows in a general south/southwesterly direction and, second, because the only residents directly affected by ground water are those who used well water.

Upon review of these conclusions, it was decided, in consultation with the EPA staff, that further examination of the real estate market in Pleasant Plains might well permit either accepting or rejecting with considerable confidence, for that area, the principal hypothesis of the study. At the same time it was concluded both that no further work on the Andover site was justified and that extension of the study to at least one additional site would increase the ability to evaluate the hypothesis. Phase II was undertaken as a consequence of these decisions.

PHASE II

I. Introduction

Phase II consisted of further examination of the Pleasant Plains site and of a search for a third hazardous waste site to study. The remainder of this volume is devoted primarily to the documentation of the second phase of the analysis of Pleasant Plains. The discussion of the search for sites is found in Appendices A and B.

Empirical work on the Pleasant Plains sample in Phase II was directed towards rectifying the shortcomings of the first phase, described in the preface. The following steps were taken:

1. The size of the pre-1974 sample was increased in the area as a whole, and the size of the post-1974 sample was increased, with emphasis placed on the area between 2.5 and 3.5 miles from the hazardous waste site, an area previously not sampled.[1]
2. More information was collected on both the extent of contamination and the impacts on individual households of the local ordinances.
3. A method was utilized which would indicate in a general fashion whether the hazardous waste site depressed values more in one direction from the site than in others.

Although it was not possible to increase the size of either sample in some sparsely populated parts of Pleasant Plains, both samples were successfully extended to the ring between 2.5 and 3.5 miles from the site. In addition, more information was collected on the contamination

---

[1]For both samples, more data were collected particularly within the first 1/2 mile of the site, within 1-1/4 to 2-1/4 mile range and from 2-1/2 to 3-1/2 miles.

episode. In particular, information was obtained on a separate discovery in 1976 of contaminated wells in a neighborhood known as the "Dugan's Lane area." With this information and with information already collected on the 1974 contamination episode and on well users, it was possible to identify the individual wells which had been ordered sealed and when these orders had been promulgated.

Although information was collected on the extent and nature of contamination of individual wells, the available data were not of sufficient quality[2] to improve significantly the definition of the zone of contamination and therefore, the contamination proxy. For this reason, the new contamination data were not used in Phase II. Altogether four models were developed for Phase II to analyze the enlarged and improved data set. One model was developed to facilitate a comparison between Phase I and Phase II, the second to test new information on contaminated wells and a third and fourth to test a refined distance variable which accounted for direction as well as distance from the site.

The bulk of this report describes the results of these efforts to reach a conclusive finding about the validity of the primary hypothesis in Pleasant Plains. In Chapter II, we describe the models used in Phase II and in Chapter III the results generated from them. Concluding remarks on the results of the Pleasant Plains sample are contained in Chapter IV. There are four appendices. Appendix A contains a description of the search for a third hazardous waste site. Appendix B is taken directly

---

[2]The monitoring data were of poor quality. Sampling methods and the range of pollutants sampled were inadequate for determining for all wells in the area whether high levels of chemicals emanating from the dump were present.

from Volume I, Appendix B; it lists and describes the site selection criteria used in both phases of this study. In Appendix C, the results of the empirical analysis in Phase II and a description of all the variables included in the models used to examine the Pleasant Plains sample are described. In Appendix D, we address some of the comments and suggestions made by reviewers of the first phase.

II. The Method

The form of the new econometric models and the data bases used in Phase II are described in this chapter. The four models are identical with respect to the independent variables representing date of sale, house characteristics, lot area and locational characteristics.[3] They differ only with respect to the nature and form of the variable which is introduced as a proxy for the effect of the hazardous waste site. For the proxy variables, in Models 1, 3 and 4, distance or direction from the site is used, while in Model 2, a form of the contamination proxy is used. Model 1 is the most general specification of the distance variable and represents the basic model of the study. The proxies used in Models 2, 3 and 4, are more narrowly defined. The purpose of defining the proxies more narrowly was to examine the more detailed information collected in Phase II on the location of individual houses and on the contamination incident.

The principal hypothesis is the same for all models: the hazardous waste site depressed the value of property in its vicinity relative to more remote property. Secondary hypotheses have been developed concerning the nature and pattern of the response of real estate markets to the hazardous waste site and were examined in Models 2, 3 and 4. Some of these were developed in Phase I and they are explored further in Phase II. Phase II, in particular, examines in more detail the response of well users to contamination of their individual wells and to government intervention. A description of the models used to test the hypothesis is presented below.

---

[3]These are also specified in essentially the same way as in Model 1, Phase I (Vol. I, p. 31 and Appendix C, below).

A. Model 1[4]

Model 1 is specified as follows:

$$LPV = a + bX + cY + dT + eD + u$$

Where D is the set of dummy variables each representing 1/2 mile zones measured linearly from the hazardous waste site, LPV is the sales price of each house sold during the study period; the price is specified in log form. X is the vector of housing and lot characteristics, Y of locational characteristics and T a series of dummy variables denoting the date of sale. The detailed specifications of X and Y appear in Appendix C.

Model 1 tests the primary hypothesis by comparing property values before and after the contamination incident (before and after 1974), as well as by comparing property values as a function of distance, using the post-1974 sample only.

One hundred seventy (170) observations were added in Phase II to the post-1974 sample for a total of 630 observations, and 167 were added to the pre-1974 sample for a total of 383 observations. The majority of the new observations in both samples were of sales of houses between 2.5 miles and 3.5 miles from the hazardous waste site. As pointed out in the Preface, data drawn from this ring were expected to indicate a leveling of values of properties far enough away from the site so that, we assumed, they were uninfluenced by it. In order to eliminate deficiencies in the original sample, the new observations are concentrated to the south and southeast of the hazardous waste site, between the towns of Pleasant Plains and Toms River. The neighborhoods were chosen because of their

---

[4]This model is virtually the same as Model 1, Phase I.

similarity to those in Pleasant Plains and because there are no major amenities or disamenities close to them which would necessitate adding new variables to the equation. This model, describing the new as well as the original observations, was the same as Model 1, Phase I, with the exception of four new variables which accounted for nearby schools, two additional zone variables, and two additional sales-date dummy variables. The introduction of these new variables was not expected to change the outcome of the basic model significantly. Also, the quarter mile zones (Model 1, Phase I) were aggregated into half mile zones in Phase II because some of the quarter mile zones were too sparsely populated to generate a reasonably sized sub-sample. Efforts to increase the size of the sample in these sub-areas met with only limited success. The results of this model, run both with the (Phase I) orginal sample and the (Phase II) enlarged sample, are presented in Chapter III.

B. Model 2

Model 2 is specified as follows:

$$LPV = a + bX + cY + dT + eC + u$$

Where X, Y, T and LPV are as defined in Model 1, and where C is a set of dummy variables defined by the experiences of individual housing units with respect to the contamination episode.

In Phase I property values of residences in the contamination zones were not statistically different, ceteris paribus, from those of properties outside the zones. Furthermore, the zones were not thought to be accurate indicators of contamination. For these reasons the post-1974 sample was subdivided to explore the effects of varying vulnerability to contamination and the different reactions to intervention by the government.

The set of dummy variables is as follows:

- o Residences which used only private wells both before and after 1974 and were unaffected by the ordinances. (Some were in contamination Zone II, others were outside both contamination zones.)
- o Residences which used municipal water only, before as well as after the contamination episode. These were located either in contamination Zone II or outside the contaminated area and were unaffected by the local ordinances.
- o Residences which, before 1974, used wells that were found to be contaminated in February 1974 and were ordered sealed within a month. These residences, which consisted of all residential units in Zone 1 built before 1974, were hooked up to the municipal system in November of that year.
- o Residences which, prior to 1976, used wells that in 1976 were found to be contaminated and which were switched to the municipal system later that year. These were situated in the southeast quadrant of Zone II.
- o All residences built after 1974 in Zone I. These used only municipal water, as the drilling of private wells was prohibited.

The model was expected to provide insights into the effects on property value associated with the contamination of individual wells, government intervention, and of damages incurred beyond those ameliorated by government action. To test directly the hypothesis that contamination depresses real estate prices, information was gathered on individual

transactions in Zone I, where contamination was detected in 1974, and in the area referred to as the "Dugans Lane area," found to be contaminated in 1976. The prices of individual contaminated units before contamination was discovered were compared to prices in the area after contamination was discovered.[5] Assuming that all factors other than contamination are held constant in the model, prices are expected to be lower after discovery of contamination.

The government intervened almost immediately, requiring the sealing of wells and reliance on municipal water. To the extent that intervention reduced either actual risk or the perception of risk, it would have reduced or irradicated any property value impacts. In addition, the government's response may have reassured other residents, especially well users, in the area that any further damages would also be taken care of at public expense. The difficulty associated with testing such a proposition is that it involves separating the reaction of price to contamination from the reaction of price to the government ordinances and other action. However, it is possible to test the effect of government action indirectly. Government action for the most part replaced well water with municipal water for individual users.[6]

A comparison between values of property with well water available and with only municipal water available was expected to generate information

---

[5]In dealing with these two sub-samples, in only one case were the post-contamination prices compared with the pre-contamination prices, i.e., for the Dugans Lane sub-sample. Time and budget considerations did not permit the same examination for the other sub-sample.

[6]New, post-1974 users of well water in Zone II were ordered to dig their wells deeper.

about preferences. On the basis of reports received from local officials and residents,[7] we concluded that well water is valued more highly than is municipal water. A switch to municipal water, particularly because of evidence of contamination, would be expected to depress property values relative to those where wells were not found to be contaminated and where, therefore, wells could still be used.

Unfortunately, however, it is not possible to isolate the impact of these preferences from other consquences of using wells versus municipal water. An important consequence of switching to a municipal water supply is that it leads to a reduction in fire insurance premiums, which, by being capitalized, tends to increase, rather than to depress property values. A comparison between the property values associated with well water and those associated with municipal water should reveal the net effect of government intervention, that is, it should show whether the savings on the cost of fire insurance adequately compensates residents for their loss of well water and for any other losses experienced as a consequence of contamination. Given the two countervailing forces, it was not possible to predict the sign of the relevant coefficients.

It was also possible to get some indirect insights into contamination and intervention by comparing two sets of post-1974 sales: uncontaminated individual units which used municipal water throughout the period and those that switched to municipal water because of contamination. This comparison avoids the issue of fire insurance because both sets of houses

---

[7]Interviews were conducted with Pleasant Plains residents, and with Atlantic Coast Realty, Inc.

used municipal water at the time of the transaction. Because of a likely subjective negative response to contamination, the prices of units which were ordered to hook up to a municipal system might be depressed relative to prices of those which had always used a municipal system.

C. Models 3 and 4

Model 3 is specified as follows:

$$LPV = a + bX + cY + dT + eQ + u$$

Where Q consists of 4 quadrants, SE, SW, NE, NW with the origin at the hazardous waste site.

Model 4 is specified as follows:

$$LPV = a + bX + cY + dT + eDQ + u$$

Where DQ is a set of dummy variables specified in terms of their direction (SE, SW, NW, NE) and distance from the hazardous waste site.

Models 3 and 4 were used to explore the question of whether a symmetrical specification of the distance variable, as used in Phase I is, in fact, an appropriate specification of the perceived disamentity of the hazardous waste site. Since contamination is known to have spread in a south/southwesterly direction, we might expect, if the uniform distance variable is inappropriate, property values in that quadrant to be depressed relative to those in other quadrants. In addition, properties further from the site in the southwest quadrant might be expected to be as greatly depressed as those closer to the site in another quadrant. Both of these propositions were tested.

Unfortunately it was not possible to collect data on house sales southwest of the site outside of the contamination zone. Consequently, to test the proposition of asymetry in the disamenities effect of the

site, it was only possible to compare property values in the northeast, northwest and southeast quadrants of the entire area sampled with property values in the southwest quadrant inside the contamination zone.

III. Results

In the previous chapter, the four models which were used to test the principal hypothesis of this study were described. In this chapter, the results of the application of the models are presented.

A. Model 1

In the first phase of the project, Model 1 was used in an effort to isolate the effect on property values of distance from the hazardous waste site. The same model was used to analyze enlarged samples of the second phase. As in Phase I, the model was applied to two data sets, a sample of transactions which occured before the discovery of contamination in 1974 and a sample of transactions which occurred after the discovery.

A comparison of the results of both phases of the project is presented in Table 1 of Appendix C. The equations underlying these tables are in semi-log form; consequently, the coefficients shown in the table can be interpreted as showing the percentage change in price associated with each independent variable. The enlarged (Phase II) post-1974 sample was used in Run 1, the original post-1974 sample in Run 2, the enlarged pre-1974 sample in Run 5, and the original pre-1974 sample in Run 6. The coefficients of the distance variables and their associated statistics are presented in Tables 1 and 2. A comparison of the coefficients of the distance variables is presented graphically in Figures 1 and 2.

Run 1 with the enlarged sample seemed to provide reliable results in terms of goodness of fit ($\overline{R}^2$) and in terms of statistical significance for the individual variables (F statistics). While the $\overline{R}^2$ is lower with the enlarged sample than it is with the original sample, it is still very

Table 1

Distance Gradient After Contamination

Distance (D) in Miles from HWS	Coefficients		F Statistic		Number of Observations	
	S_e Run 1	S_o Run 2	S_e	S_o	S_e	S_o
$0.5<D\leq1.0$	-0.025	0.004	0.59	0.02	228	227
$1.0<D\leq1.5$	-0.056	-0.006	2.10	0.03	82	63
$1.5<D\leq2.0$	0.009	0.086	0.04	5.13*	68	65
$2.0<D\leq2.5$	-0.013	0.082	0.08	3.53**	101	76
$2.5<D\leq3.0$	-0.053	--	0.71	--	57	--
$3.0<D\leq3.5$	-0.071	--	1.22	--	63	--

*Significant at the 95% level.
**Significant at the 90% level.
S_e = enlarged sample; S_o = original sample; HWS = hazardous waste site.

Table 2

Distance Gradient Before Contamination

Distance (D) in Miles from HWS	Coefficients		F Statistic		Number of Observations	
	S_e Run 5	S_o Run 6	S_e	S_o	S_e	S_o
$1.0<D\leq1.5$	0.061	0.058	3.76**	2.32	33	24
$1.5<D\leq2.0$	0.045	0.102	1.35	1.34	34	29
$2.0<D\leq2.5$	0.055	0.144	1.52	1.44	86	38
$2.5<D\leq3.0$	0.091	--	2.05	--	17	--
$3.0<D\leq3.5$	0.010	--	3.90*	--	47	--

*Significant at the 95% level.
**Significant at the 90% level.
S_e = enlarged sample; S_o = original sample; HWS = hazardous waste site.

Figure 1

Distance Gradient After Contamination

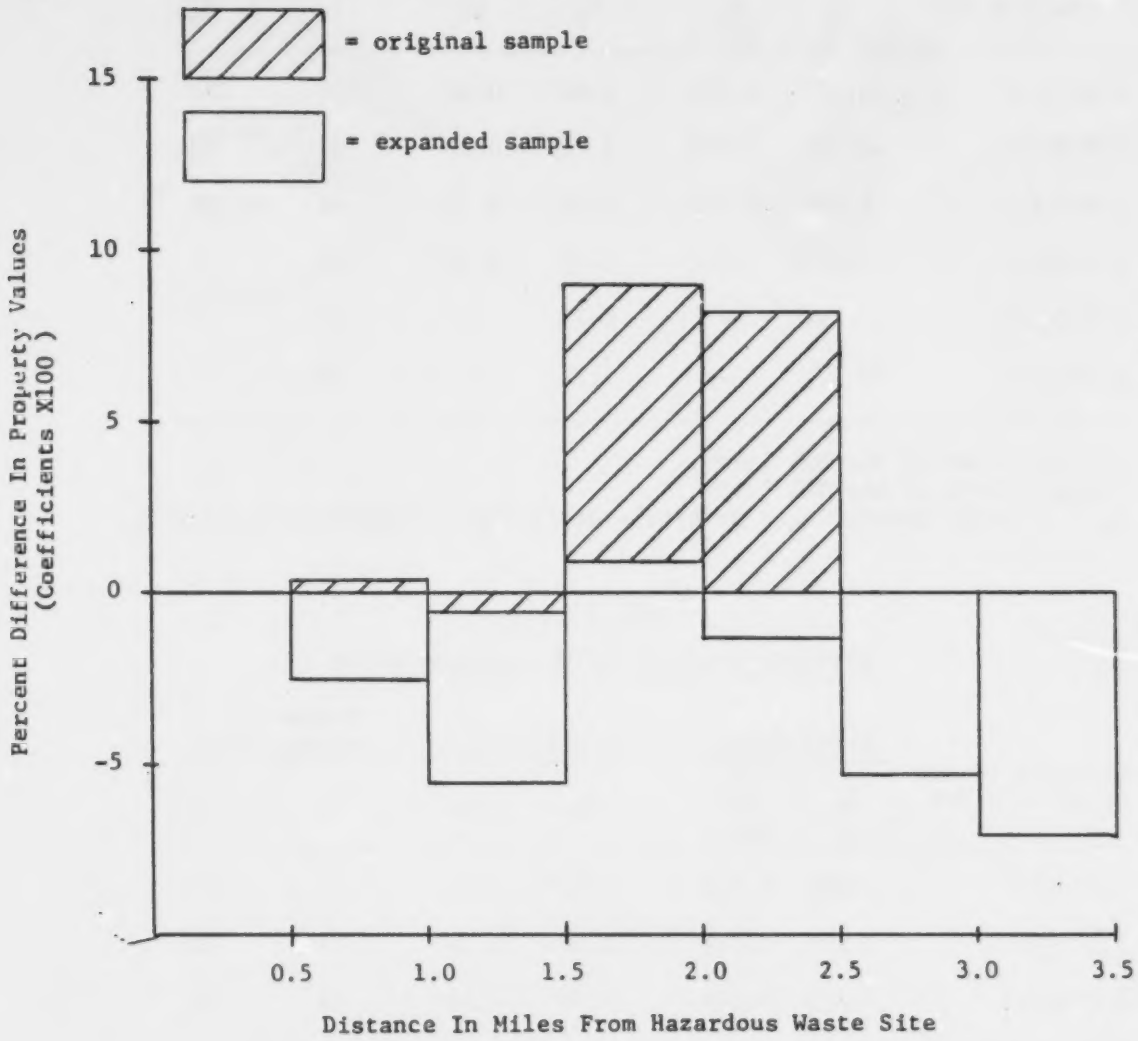
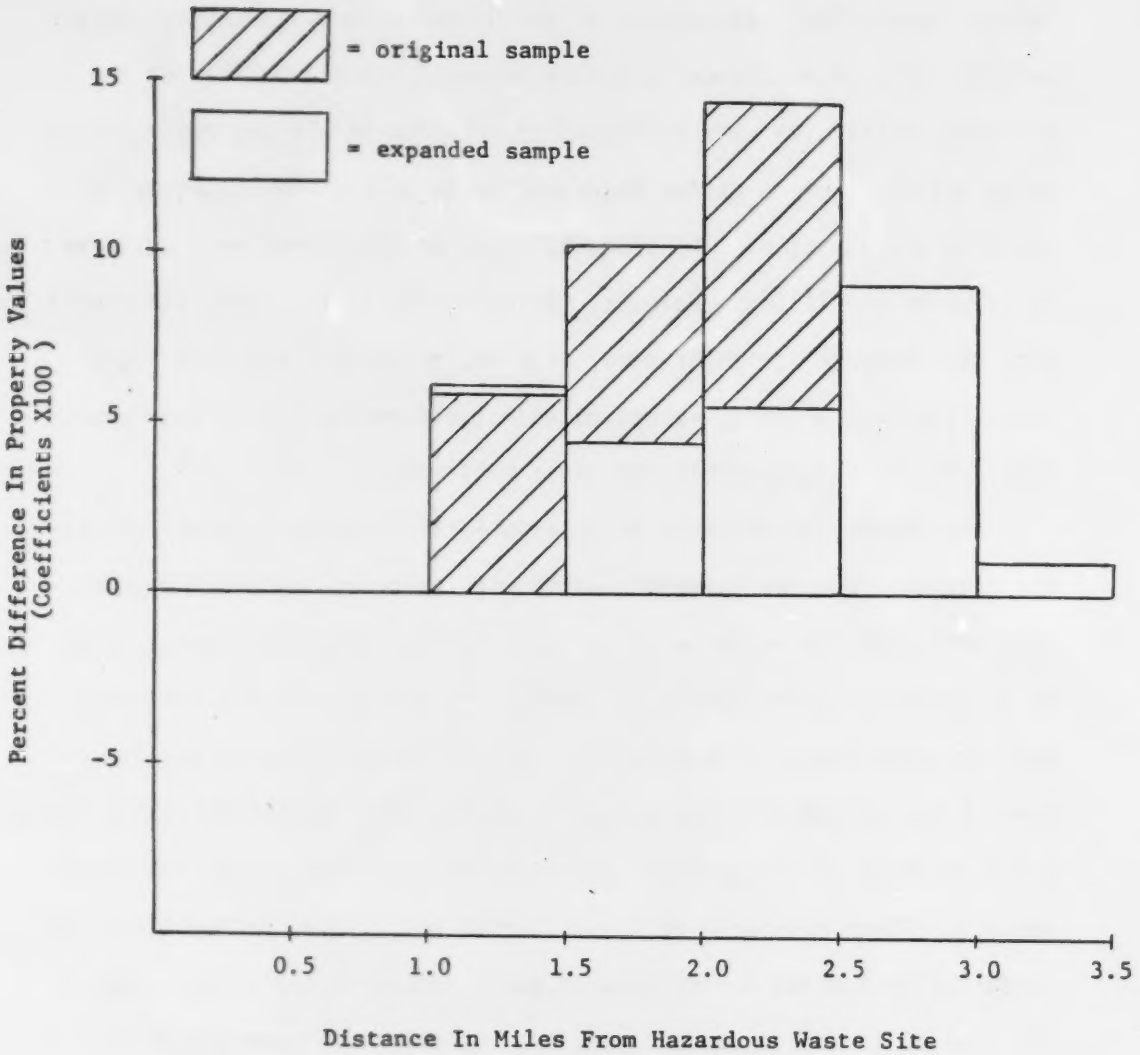


Figure 2

Distance Gradient Before Contamination[1]



[1]There was an insufficient number of observations between 0 and 1 mile to derive the sample between the two half mile zones.

high, i.e., .85. Table 1 demonstrates, however, that, contrary to the primary hypothesis, when the model is run with the enlarged sample, no statistically significant (at the 90% level) differences in values were found between properties close to the hazardous waste site and those further away. The coefficients of the distance dummy variables representing sales of residences situated between .5 and 3.5 miles of the hazardous waste site were estimated in relation to the one representing sales within .5 miles of the hazardous waste site. The latter was omitted from the equation. The expected signs of the former were positive relative to the latter. However, the estimated coefficients associated with the distance variables have, with one exception, negative signs suggesting that property values outside the first half mile are lower than property values within the first half mile.

The absence of evidence of an association between property prices and distance from the hazardous waste site using the enlarged sample, contrasts with the evidence of the weak but positive association found by using the original (Phase I) sample. An analysis of the post-1974 data was undertaken in an effort to explain these different results. Model 1 was tested with the enlarged sample, omitting all variables introduced in Phase II to represent amenities/disamenities in the new areas sampled. These consisted of school variables. Since, in the first run these had been added to the model,[8] their inclusion might have reduced the size of the distance coefficients. However, as demonstrated in Table 1, Appendix C, Run 4, this does not appear to have happened. The distance

---

[8]Two zone variables were also introduced in Phase II.

coefficients were not substantially different, in the run in which the schools were included (Run 1), from those in the one (Run 4) from which they were excluded.

A further analysis, undertaken to explore the possible reasons for the differences between the two "price gradients" presented in Figure 1, consisted of a comparison between the coefficients of the variables in the model (other than those associated with the distance variable) generated with the original sample on the one hand, and the coefficients generated with the enlarged sample, on the other hand. Such a comparison suggests that the observations added to the original sample were not sufficiently different in character to change the signs or the magnitude of virtually any of the coefficients.

Nevertheless, when the new observations (the enlarged minus the original sample) were run separately from the original sample (Run 3), some differences between the original and the new sample became apparent.[9] In the new sample, lot size, age and house area, among others, were not statistically significant; the coefficients associated with lot size, garage and fireplace did not have the predicted sign; and the coefficient associated with house area was much smaller than in the original sample. Some differences between the samples could be expected because of the smaller size of the new sample and because the new sample was drawn from a different part of the Toms River/Pleasant Plains area. The latter was, of course, by design. However, the differences in the coefficients associated with lot size and house area, for example, are not readily explained.

---

[9]The new sample was run separately solely for the purpose of analyzing the differences between the original and the new data set.

The new enlarged pre-1974 sample was also tested using Model 1 and the results were compared with those generated by the original sample in Phase I. The coefficients associated with the variables in the model are presented for each sample in Table 1, Appendix C, Runs 5 (the enlarged sample) and 6 (the original sample). A relationship between property values and distance from the hazardous waste site is not expected before contamination was discovered in Pleasant Plains. The Phase II results suggest, as expected, that prices of houses were not associated with proximity to the hazardous waste site before 1974. The fact that the coefficients associated with the distance dummy variables were not statistically significant at the 95% level in either the original or the enlarged sample demonstrates that the hypothesis of "no relationship" is substantiated in Phase II.[10]

The positive signs associated with the distance coefficients (reflecting greater remoteness from both the hazardous waste site and Pleasant Plains) in both the original and in the enlarged sample suggests that, in the pre-discovery period, Pleasant Plains was a relatively undesirable place to live. However, the fact that the distance coefficients associated with the enlarged pre-1974 sample, are generally smaller than those generated by the original sample suggests that the undesirability of Pleasant Plains in the pre-discovery period was not as pronounced as the Phase I results indicated.

---

[10]It is important to note that the distance coefficients associated with the enlarged sample have higher F statistics than those associated with the original sample. Also, two of the distance coefficients are statistically significant at the 90% level in the enlarged sample.

Enlarging the sample appears to have improved the descriptive power of the model. More coefficients in the enlarged sample have the predicted signs than in the original sample.[11] The coefficients associated with age of house, lot size and basement have the "correct" signs in Run 5 (the enlarged sample) whereas they do not in Run 6 (the original sample). Since the enlarged sample has improved the descriptive power of the model, it has increased the reliability of the distance variables.

The results for the pre-1974 enlarged sample are compared with those for the post-1974 enlarged sample in Figure 3. It must be emphasized that neither of the gradients is statistically significant at the 95% level, although parts of the pre-1974 gradient are significant at the 90% level.[12] Nevertheless, the signs of the coefficients, as indicated previously, suggest that the changing status of Pleasant Plains during the 1970s may have been more important in determining property prices than the hazardous waste site. The positive association before 1974 between distance and property prices using the original sample had been attributed, in Phase I, to the fact that Pleasant Plains was, before 1974, a less desirable place to live than were neighboring areas. A similar finding with the enlarged sample reinforces this interpretation.

As already noted, after 1974, in contrast to the original work, the expanded sample showed a negative, rather than the predicted, positive relationship. The positive but weak and inconsistent relationship between

---

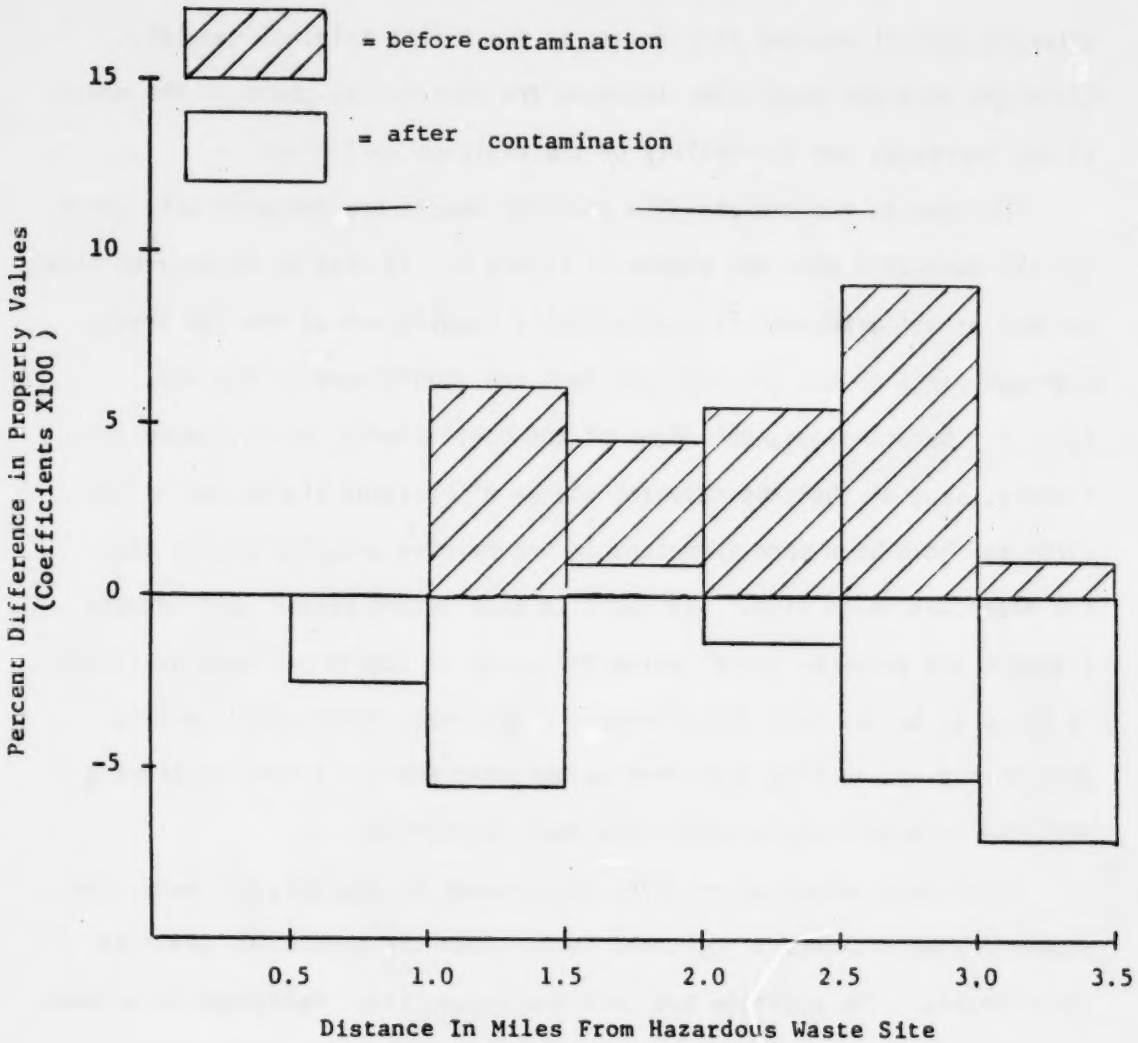
[11] There is, however, virtually no difference between the $\bar{R}^2$ of the two samples.

[12] The distances between 1 to 1.5 and 3.0 to 3.5 mile rings are significant at this level.

Figure 3

Distance Gradient Before and After Contamination[1]

(Expanded Sample)



[1]The number of observations between 0 and 1 mile in the "before contamination" sample was too small to divide the sample between the first two half-mile zones.

distance and property values after 1974 in Phase I was attributed, in Volume I, to the fact that the positive effect on property values of the preference to live in Pleasant Plains was as strong as the negative effect of the hazardous waste site. The negative relationship established with the enlarged sample suggests that the preference to live in Pleasant Plains was, in fact, the stronger force after 1974. However, this conclusion is only tentative since none of the coefficients on the distance variables is significant at the 90% level.

B. Model 2

Model 2 contains more detailed information on the contamination episode and government reaction to it, in our effort to ascertain the consequences of both. The results of the model are presented in Table 1, Appendix C, Run 7, and are described below:

- o There is no evidence that private well water is more highly valued than municipal water;[13]
- o Properties with wells that were determined to be contaminated in 1974 apparently did not sell at lower prices after that date, than did those with wells which were not determined to be contaminated.
- o House prices responded negatively but weakly to the 1976 discovery of contamination in Dugan's Lane. Prices of houses after 1976 in the contaminated area appear to be depressed both relative to houses with uncontaminated private wells

---

[13]The coefficient associated with "municipal water" was not statistically significant at the 90% level (the omitted dummy variable was "well water").

and relative to the houses in the same area that were sold between 1974 and 1976.[14]

- o Prices of houses which were built in 1975 in the area which was determined to be contaminated in 1974, i.e., Zone 1 and which were built to use municipal water only, were high relative to the prices of houses using well water only (outside Zone 1).

The evidence that contamination depressed prices is, on the basis of the above, weak and difficult to interpret. On the one hand, there is some weak evidence that the 1976 discovery of contamination may have depressed the prices of the affected houses. On the other hand, the discovery of contamination in 1974 does not appear to have had any impact on the prices of the affected houses.

In fact, the results for the houses whose wells were found in 1974 to be contaminated are difficult to interpret. The signs of the coefficients associated with houses with wells found to be contaminated in 1974 are different from those associated with houses built in 1975 with municipal water in the same zone. The fact that the prices of houses built in 1975 in the same zone, i.e., Zone 1, were actually higher, ceteris paribus, than prices of houses built before 1975 in that zone, suggests that the price of contaminated properties located in the same area might have been still higher had they not been contaminated. This interpretation is consistent with the observation made in Phase 1, that the model does

---

[14] Very few observations were available for the sales between 1974 and 1976 in the Dugan's Lane area. Ideally pre-1974 transactions should have been included. However, this step was not taken because of time and budget constraints.

not capture some amenity in Zone 1. However, it seems more probable that, since all the post-1974 properties were part of a single development, they have characteristics which are different from houses built before 1974 and which are not accounted for by the model.

C. Models 3 and 4

The final test of the effect of the hazardous waste site on property values consisted of an attempt to improve the specification of the distance variables. One specification differentiated the observations into four quadrants and the other specified distance from the waste site linearly within each quadrant. These results are presented in Appendix C, Table 1, Runs 8 and 9.

Since ground water flows in a general southwesterly direction, the coefficients associated with the northeast, northwest and southeast quadrants were expected to be algebraically greater than the one associated with the southwest quadrant (Model 3). Also, at any given distance from the site, properties were expected to be more depressed in the southwest quadrant than in other quadrants (Model 4) suggesting a smaller coefficient (positive) on the former relative to the latter. The results of using these models show that respecifying the proxy variable to adjust either for direction from the hazardous waste site or for a combination of direction and distance from the site, does not generate evidence that the hazardous waste site affected house prices. Contrary to the prior hypothesis, all the coefficients associated with distance from the site including the one associated with the southwest quadrant had negative values. In addition, none of these coefficients was significant at the 90% level.

Similar results were obtained for the simple directional dummy variables. The F statistics of all three coefficients of the variables included in the equation were below the critical level of significance (below 1). Further, the coefficient representing the southwest quadrant was larger than the others.

IV. Conclusions

Two kinds of conclusions are drawn from the Public Interest Economics Foundation's application of the property value technique to ascertaining the economic consequences of individual hazardous waste sites and the associated appraisal of the technique as an instrument for regulatory analysis. The first is the empirical findings about the sites studied; the second is more general conclusions about the validity and utility of the method. In addition, it is appropriate to comment on the significance of this study in evaluating the benefits of regulating hazardous waste sites.

A. Empirical Findings

The analysis of the Pleasant Plains real estate market performed in Phase II supercedes that performed in the first phase, by virtue of the fact that the second phase incorporated both a more complete sample and techniques designed to answer questions raised in the first attempt. The analysis, in Phase I, of Andover, Minnesota, stands as the most advanced analysis of that site that is feasible with any reasonable expenditure of resources. Consequently, with few exceptions, the empirical findings sited here pertain to the Phase II analysis of the Pleasant Plains hazardous waste site.

The principal hypothesis of this entire study is that the values of property in the vicinity of a hazardous waste site are depressed relative to values of property further away.

There is every reason to expect on *a priori* grounds that the hypothesis is valid. The logic is simple: Both existing hazardous waste dumps and all other real estate parcels (in an area) are fixed geographically.

Consequently, if the dump is in fact a disamenity, its presence should decrease the psychic income that could be generated by neighboring real estate; that reduction should be capitalized in the value of the property. Presumably, the less the impact of the disamenity, the less property values would be affected by proximity to the dump; hence, the value of property further away should, in general, be depressed less than adjacent property. The theoretical bases of the hypothesis were reinforced by successful application of property value analysis in evaluating other kinds of locational amenities and disamenities as well as by the "common knowledge" that location is a, if not the, dominant factor in the determination of the value of residential real property.

In this study it proved impossible to verify the hypothesis empirically. This is the major empirical finding of the entire effort. It applies to both phases of the study of Pleasant Plains and to that of Andover. The preponderance of evidence failed to show any relationship between the hazardous waste site and the prices of nearby residences. While there was some very weak evidence that the prices of residences using well water that was found to be contaminated were depressed relative to other properties using well water, no measurable general disamenity effects associated with proximity to the hazardous waste site were found.

In light of the plausibility of the hypothesis, the failure of the empirical effort to validate it raises serious questions. There are a limited number of possible explanations of the result. The first set pertains to the PIE-F study itself and the second to the methodology in general.

B. The Study

The PIE-F study could have been deficient in either of two respects: the Pleasant Plains site could have had some peculiar characteristics that made it an inappropriate laboratory for testing the method, or the PIE-F analysis could have been internally faulty.

Addressing the latter first, while it has only been possible to examine a limited number of econometric techniques in this study, the probability that any other techniques or methods of analysis would yield results different from those obtained in this analysis is low.[15] Outside reviewers have also supported this view; several of them suggested further refinements of the analysis, but none suggested that these refinements would alter the basic results.

This leaves the possibility that the Pleasant Plains (and Andover) site was inappropriate and that the selection of alternative sites would have provided a more propitious test of the technique. In fact, the efforts of the study team to find an additional site even as good as Pleasant Plains proved virtually fruitless, as is explained in Appendix A. Nevertheless, there are some infirmities associated with the Pleasant Plains site and some specific aspects of the analysis that warrant comment here.

Several explanations of the failure of the tests to confirm the principal hypothesis have been put forward explicitly or implicitly in the course of this report. They include problems associated with inadequate

---

[15] This view is primarily supported by the fact that the regression results were reasonably consistent throughout the analysis; they predicted property values with adequate confidence and virtually all of the coefficients had the expected signs.

data, the collocation of the hazardous waste site with other sources of disamenities or amenities and ameliorative action taken by the government or as a consequence of government action.

Inadequacy of data was primarily responsible for the difficulties associated with specifying the variable serving as a proxy for the effects of the hazardous waste site. The (small) size of the sample of observations close to the site made it difficult to measure adequately the impacts on property values at short distances from the site. Further, the lack of reliable evidence of contamination or its precise location made it impossible to create a completely satisfactory contamination proxy for the magnitude of the disamenity in the Pleasant Plains/Toms River real estate market.

Another problem with the use of the Pleasant Plains site arises because discovery of contamination attributable to the Pleasant Plains hazardous waste site occurred during a period in which the values of properties relatively close to the dump were appreciating in response to increased popularity of the area. Discussion with real estate dealers and other individuals in Pleasant Plains indicated the increase in popularity and that it was associated with the development of a new retirement community built close to the site. The change in the quality of housing over time in the area close to the site constitutes a violation of the homogeneity assumption underlying regression analysis. Consequently, it was impossible to separate any negative impacts on values associated with the site from the positive impacts of residing in a preferred area.

Another factor which complicated the testing of the proxy variables was the ameliorative action undertaken to reduce current adverse consequences and future risks associated with the site. The government's

action occurred almost immediately after contamination was discovered. To the extent that ameliorative action reduced actual and potential damage and the perception of damage or risk, it should eliminate any downward pressure on property values attributable to actual contamination.

C. The Method

The examination of the Pleasant Plains site and its associated real estate market suggests that application of the land value technique to individual sites as a method of estimating the potential benefits of the regulation of hazardous waste sites is not useful. This is entirely contrary to the expectations of the PIE-F research team at the beginning of the project. This conclusion is based on the prevalence of several, somewhat overlapping, sets of factors that appear to obstruct the use of the technique rather generally.

The method imposes some requirements on empirical analysis that are difficult to fulfill in any individual case and that, therefore, are likely to be impossible to fulfill in a large enough number of cases to permit general application of the method. The method involves predicting the prices of parcels of real estate as a function of some measure of disamenity, inter alia. To reflect the factors in addition to the distance or contamination measure of the disamenity, it proved necessary to include a total of 43 raw variables from which over 150 parameter values were developed. It is possible that important factors were still left out. Thus, a large number of observations close enough to the site to have the potential of being perceptibly affected is required. This, in turn, dictates that the site be in an urban residential area. As discussed subsequently, the use of such a site introduces some factors that can be

expected to obscure any actual impact of the hazardous waste site on property values in the affected market.

In order for the health risks and other disadvantages of living close to a hazardous waste site to affect psychic income and, hence, property values, the nature of the disadvantages must be appreciated by participants, both buyers and sellers, in the housing market. Otherwise, a land value analysis could not produce valid estimates of the potential value of reducing or eliminating the disamenity. Should some of the effects--such as health impacts--be long delayed or should the existence of hazardous substances in a site not be widely known, housing prices could not reflect the negative value of exposure to the risks.

Further, for a before-and-after analysis of housing prices to be meaningful, there must be an identifiable period in which the population first becomes aware of the problem.

The importance of awareness affects the appropriate method of analysis. Future efforts to employ land value analysis might well be accompanied by surveying the population to determine the extent and timing of awareness. While it is possible to observe parts of the process by which market participants learn of a disamenity, particularly the type of information disseminated by governments and in the media, little is known about residents' perceptions. The lack of information about the perceptions of buyers and sellers as to the characteristics of a hazardous waste site, means that proxy variables must be used. These can be based only on somewhat arbitrary judgements about potential disamenity effects.

In order for a gradient in property values to be attributable to a hazardous waste site, it is necessary that the site not be collocated

with any other important disamneity or amenity. The consequence of collocation is that it is difficult to isolate the impacts of one amenity or disamenity from the others. In cross-sectional analysis, it may be impossible to do so where the (dis)amenities are often very close together. In before-and-after studies, in any case where more than one collocated disamenity (or amenity) changes over time, it is again, predictably, impossible to separate the effect of one amenity or disamenity from the others.

The fact that governments react also complicates the analysis. Ideally, for purposes of analysis, a hazardous waste site should be left alone while the real estate market has an opportunity to reach a new equilibrium reflecting the value of the disamenities created by the site. However, with reasonably responsive local governments, it is far more likely that the adverse impacts of any site will be eliminated or offset, in whole or in part. To the extent that such action is taken at public expense and to the extent that it is both effective and perceived to be effective, there is no subsequent loss of value of real property in the area. In such circumstances, observations of real estate prices would not reflect the economic value of regulating the site. Even if the ameliorative action is taken at private expense, if it required a one-time expenditure rather than continuing outlays, amelioration, once accomplished, would have created only a sunk cost which can have no subsequent influence on values. Should there be doubt as to the efficacy of ameliorative action, the risk of future disamenities would, of course, tend to depress prices of proximate property somewhat.

In general, if the consequences of a hazardous waste dump were serious enough to cause a substantial impact on property values, they

would, at least partly for that reason, tend to cause ameliorative action to be taken. Thus, the more likely it is that market forces would produce discernible impact on real estate prices, the more likely it is that political forces would eliminate or reduce that impact.

In addition to the practical problems just discussed, there are two other major problems which undermine the usefulness of the technique. First, a hazardous waste site is a land-intensive activity. Consequently, ordinary prudence in minimizing the cost of an economic activity would lead to the location (either legal or illegal) of dumps in areas where land values are low. Thus, there is an identification problem built into the analysis by the nature of the phenomenon being analyzed. Second, a hazardous waste site may not constitute a disamenity to all land users. For example, the costs of carrying on some industrial activities may be reduced by proximity to a site for disposal of the hazardous wastes they generate. Any such cost saving would tend to be reflected in higher land rents.

Finally, it is necessary that the real estate market from which observations are drawn be homogeneous. One of the problems with the Pleasant Plains study is that the "quality" of the neighborhood improved during the period under analysis. In a sense, this can be considered to be a form of collocation, but one that varies over time.

One of the consequences of these constraints imposed by the method itself is, as has already been mentioned, that the number of sites suitable for analysis is very small. For example, collocation with hazardous waste sites of other disamenities or of amenities was found to be common in urban areas. Further, ameliorative action often was found to have

taken place soon after any problem was discovered--presumably, in a majority of cases, as a consequence of a responsive political system. Our search in Phase II for sites suitable for empirically testing the property value techniques suggests that it is difficult to find hazardous waste sites suitable for applying the technique.

D. The Benefits of Regulating Hazardous Waste Sites

It is essential to make clear that the failure to identify any effect of proximity of a hazardous waste site on property values does not suggest that the economic cost of hazardous waste sites is small or that, similarly, the benefits of regulating them are not potentially large.

First, the inability to exclude the effects of collocation of other activities that "seek" low cost locations and that generate disamenities means that the effects of a hazardous waste site in isolation tend to be underestimated. Presumably each collocated disamenity makes a marginal contribution to downward pressures on prices in the nearby area, but lack of variation in the presence of disamenities precludes estimating the marginal effect of each. Similarily, removing or mitigating the effects of one such disamenity tends to increase the marginal productivity of ameliorating each of the others.

Second, the fact that the Pleasant Plains area became more desirable after the "incident" means that any adverse effect of the dump on property values was at least partially offset. Prices in the area would, presumably, have risen more than the increase actually observed had the hazardous waste site been absent or innocuous.

Third, the fact that ameliorative action was taken promptly eliminated much of the basis for any reduction in housing prices. The impact of ameliorative action suggests that the economic value of regulating a hazardous waste site may be bounded from above by the costs of amelioration if such action is entirely effective and is perceived as being so and if all costs would otherwise be embodied in the depression of property values. The latter is almost certainly not true in many cases, because of lack of awareness. If there is insufficient information as to the nature of the dump and the associated health hazards and other risks, even an ideal analysis of land values would fail to capture all the costs of the dump and therefore all of the value of regulating it.

Finally, there may be some costs that cannot be identified in any land value study, namely costs that are never appreciated or that are excessively discounted in the real estate market. The most obvious example is the cost of health risks that are not perceived during the period when the real estate market is under observation.

APPENDIX A: SEARCH FOR AN AIR SITE

An extensive search was conducted for a site which could serve as a third case study for evaluating the usefulness and validity of a case-by-case application of the property value technique for estimating the potential benefits of regulating the disposal of hazardous waste sites in residential areas.

Sites were screened in Phase II on the basis of criteria outlined in Appendix B and described briefly below. A deficient population due to the rural nature of many sites was the criterion most frequently responsible for eliminating sites in both phases. Our experience In Phase I indicated that in order to use the multiple-regression technique on a single site, a substantial population (over 15,000) is needed to generate enough house sales. Some criteria played a much stronger role in eliminating sites in Phase II than they did in Phase I. Interference from other waste sites has been the biggest problem in old industrial cities, where there are many abandoned facilities and where discoveries of buried wastes in lagoons are commonplace. In Phase II collocation of amenities and disamenities in the same geographic area was used as a criterion to reject sites. Exceptions were made only in cases in which the amenity/disamenity existed before as well as after a siting or an incident associated with a hazardous waste site and where, therefore, controlled comparisons could be made. Sites which produced potable well water contamination, but which were promptly hooked up to an alternative source of water, also were very highly discounted in Phase II. Under these circumstances, the time span between the discovery of the contamination and the hook-up

is not long enough to allow new equilibrium market prices to be reached and sufficient number of observations generated.

About 180 sites were systematically examined; a combined selection from the Superfund Interim Priority List, suggestions from superfund personnel and others, and sites investigated by ICF Incorporated. With the exception of one site (discussed below), all were rejected on the basis of the criteria outlined in Appendix B.

At the outset our goal was to find a site where air contamination predominates. The first reason for this emphasis was that the two previous case studies examined ground water contamination. Secondly, with air contamination, the likelihood of individuals being able to mitigate the effect on residential properties appeared to be reduced, since one cannot hook up to an alternative source of air as can so readily be done with water. However, we were not successful in locating many air sites, and the one which offered some potential had to be disqualified because the local government was unwilling to cooperate by making transaction data available. Eventually the set of sites was expanded to include all kinds of contamination.

Where relevant, the first step in the screening process was to screen a site simply by examining the brief description provided by the Superfund office. In general, this step served to eliminate sites because of the sample size and public awareness criteria. The feasibility of the remaining sites, as well as those not on the superfund list, had to be established through extensive telephone conversations with public health and/or city officials. The most promising air site was one suggested by an office of the U.S. EPA. It is the McColl-Los Coyotes site in Fullerton,

California. (See the table in this appendix for a description of the contamination problem for this and other sites which required more than a preliminary investigation.) This site is unique in that it met all our criteria and, in addition, was situated in a middle to upper middle income area. This latter fact made it particularly interesting because our investigation has shown that in most cases hazardous wastes operating and/or disposal facilities are sited in low income neighborhoods where property values are already low.

Because of the contamination, the city's planning commission has denied permission to three different developers to build on land adjacent to the site. The decision of the commission was based on soil tests which showed severe soil instability and high concentrations of sulphuric acid.[1] It is questionable, however, whether this site would have offered any measurable impact on existing residential properties, since the odor reportedly extended only 400 feet from the site. Moreover, the odor is a problem only on windy days. Anecdotal evidence from realtors and health engineers in the area suggests that there has been no noticeable impact on property values. This study was precluded when we were denied access to the property record cards by the Orange County Tax Assessor's office.

Seven sites, three of which were already on the superfund list, were strongly recommended by Hugh Kaufman, Anthony Deicidue and Doug Cohen, all of the Superfund office. Of these, the one with the most serious contamination was the one in Woburn, Massachusetts. A brief description of that site is given below.

---

[1]Personal communication; Barry Eaton, Chief City Planner, Fullerton Office of Development Services, to Michael Adler, February, 1982.

For years residents of Reading, a town 1/4 mile northeast and downwind of the Woburn site had complained of nausea, headache, loss of appetite, paint peeling off buildings and rotten egg odors, but it was not until 1979, when construction work began on an industrial park, that the source of the odor became apparent. The 800 acre piece of land and wetlands in north Woburn where the industrial complex was being developed was found to be scattered with the wastes of 130 years of leather, chemical and glue manufacturing. Contaminants discovered at the site include: arsenic, chromium, heavy metals, decaying animal hides, hair, carcasses soaked with chromium solution and emitting a strong odor of hydrogen sulfide.

Furthermore, epidemiological studies have indicated that: Woburn has the highest cancer rate in Massachussetts for cities over 20,000 people; cancer of liver and kidneys was very high and increasing; leukemia incidence is over two times the normal rate, particularly in East Woburn.

In that same year, two bad tasting wells in East Woburn were discovered to be contaminated and were later closed. The chemicals found in those wells were trichloroethylene and chloroform. Unfortunately for purposes of analysis, those chemicals are different from the ones found on the site of the industrial complex and, therefore, cannot be linked to that contamination. At this time, the source of the well contamination has not been identified.

For this reason, and because the hazardous waste site and the industrial park are collocated, this site had to be rejected. The collocation problem suggests possible offsetting effects, since we would hypothesize

that proximity to the dump is a disamenity while proximity to the industrial park could be valuable.

In 1981, ICF Incorporated conducted a study for the Office of Emergency and Remedial Response of the U.S. EPA in which they analyzed community involvement in hazardous waste site problems. Of the sites examined by ICF which are not on the superfund list, the Jackson Township, New Jersey, case seemed initially to be the most promising. The basic problem here is extensive ground water contamination caused by the misuse of a municipal landfill. For a number of years, the landfill accepted raw sewerage and other liquid wastes far in excess of what could be absorbed by the solid material at the site. In addition, the facility was the receptacle for illegal dumping at night. A brief history of the contamination episode follows.

In 1978, two years after residents began complaining of unpleasant odors from well water, 96 families were advised by the township to cease drinking water from their wells. In 1979, the New Jersey Department of Health announced that it had detected known carcinogens in several wells. Eventually, about 160 wells all within 1.5 miles of the site were closed.

By the middle of 1980, a municipal water system was in place, but for the interim 21 months the township government trucked drinking water to the affected residents and offered shower facilities at a school 5 miles away.

Residents from Jackson Township, as well as the Woburn site, were given national media coverage, when they testified in Washington at hearings before the Senate Labor and Human Resources Subcommittee on Health and Scientific Research, chaired by Senator Kennedy. The Jackson

Township problem was, in addition, given other national attention. For instance, it was cited in the November 1, 1982, issue of Newsweek in an article entitled "How Safe is Your Water."

Unfortunately, consideration of the site for empirical analysis had to be discounted due to proximity of 4 miles to the Pleasant Plains Township site and due to insufficient population, which would limit the size of the sample of transactions. The entire township of Jackson had a population of only 26,460 in 1981. However, this population is spread out over a wide area in small pockets. The affected area is Legler, an outlying district of some 165 houses.

At the time of writing the results of this report, we discovered a site in St. Louis Park, Minnesota, which warrants considerably more investigation. We have not been able, on the basis of our preliminary investigations, to determine the potential usefulness of this site for estimating land value effects. However, unlike the other sites examined, this one cannot be categorically rejected.

Table 1

Selected Sites

Name and Location of Site	Contamination Problem	Reason for Rejecting Site
Sites Recommended By Superfund:		
Stringfellow, Riverside, CA	Stringfellow consists of a series of artifical ponds used for the disposal of hazardous waste for about 16 years. It lies 400' in elevation above the residential area of Glen Avon, which is 2 miles away. During heavy rains, run-off produces overflows, washing wastes into residential area. Because of heavy rains and fear of dam rupture, the Regional Water Quality Control Board ordered the discharge of acid waste from the site. For 5 years in the 1970's, more than 1 million gallons were released into Glen Avon drainage channels.	o Insufficient population close to the site. (Population of Glen Avon: 8,444) o The public felt the removal operation was well managed and highly successful.
Silesum MA	Air and ground water contamination.	o Source of contamination has not been established.
Hyde Park Landfill, Hyde Park, NY	Leaking leachate from municipal landfill which runs into nearby creek.	o Absence of residential contamination.
Gray, ME	Ground water contamination.	o Insufficient population close to the site. (Population of Gray: 4,300)
General Chemical, Framingham, MA	Regulatory problem. There are new state laws governing the handling of hazardous wastes with which the company has not fully complied, as yet.	o There is no contamination problem. o There is no disposal problem.
Frayser & North Hollywood, Memphis, TN	Shallow ground water and surface water contamination. Contaminated surface runoff to the Wolf River. Alleged health effects--hair loss, rashes among children and pets.	o Contamination too limited for much expected effect. o No contamination of potable water supply. o Failure of epidemiological studies to link health effects with wastes from the hazardous sites.

Table 1 (continued)

Selected Sites

Name and Location of Site	Contamination Problem	Reason for Rejecting Site
Sites Recommended By Superfund:		
Woburn, MA	Ground water contamination of 2 private wells. Air contamination--odor problems are particularly bad on dry, windy days downwind of site. Health effects: highest cancer rate in MA for cities over 20,000 people. o Cancer is very high and increasing. o Leukemia incidence is over 2 times the normal rate.	o Collocation problem--the hazardous waste site is also the site of a large industrial complex. o The chemicals found in the contaminated wells were not the same as those found on the waste site. Source of chemicals has yet not been established.
Site on ICF List Not Previously Investigated:		
Jackson Township Landfill, NJ	Ground water contamination of private potable supply wells. 160 wells within 1.5 miles of site were closed. Epidemiological studies revealed: o Serious kidney problems. o Above normal levels of miscarriages. o Abnormal amount of vaginal infections in young girls. o Serious skin rashes after showering in well water.	o Insufficient population. o Close proximity to Dover Township site. Distance to Dover Township is 4 miles.
Other Suggested Sites:		
Simi Valley Landfill, City of Simi, CA	Ground water contamination from hazardous waste disposal of oil at landfill.	o No residential contamination. Landfill is isolated in the hills.
McColl-Los Coyotes, Fullerton, CA	Foul odor emissions from sumps on 2 adjacent pieces of property. During World War II, sumps on the 2 properties were used for the disposal of acid sludge residues from petroleum refining of high octane aircraft fuels.	o Denied access to property record cards. o Odor problems extended only 400 feet.

Bibliography

ICF Incorporated. Analysis of Community Involvement in Hazardous Waste Site Problems, A Report to the Office of Remedial Response. U.S. Environmental Protection Agency, 1981.

Office of Superfund. "Superfund Interim Priority List." U.S. Environmental Protection Agency, 1982.

APPENDIX B: CRITERIA FOR SITE SELECTION (PHASE I)[1]

Appendix B reviews the site selection process and describes the criteria employed for choosing sites. The focus is on those criteria which were not described in detail in Chapter III in the main body of Volume I.

A. Introduction

Two sets of criteria were employed in the initial site selection. The first set pertains to potential sample size, public awareness of problems associated with a site and the existence of a continuous development around a site. The fulfillment of these criteria is considered essential to an empirical investigation of hazardous waste sites. The second set of criteria is concerned with the different types of problems associated with hazardous waste sites, the extent to which these problems have been ameliorated and difficulties associated with measuring the effects of hazardous waste sites on property values. Non-fulfillment of the second set of criteria were used to rank sites in a general fashion, but did not necessarily preclude sites from consideration in Phase I.

B. Sample Size

It is necessary to obtain a sufficient number of observations to study the effects of a hazardous waste site. The size of a potential sample may be predicted by the size of the population or the number of homes in the vicinity of the site and the duration of public concern. In Phase I, a minimum of 1,000 homes or 4,000 people as well as a two-year

---

[1]The information contained in this appendix is taken directly from Appendix B, Volume 1.

period of public concern was considered necessary to generate a sufficient number of housing sales samples.[1]

C. Public Awareness

The necessary degree of concern is difficult to measure; however, a number of local indicators are available. Maybe the most important indicators are the number of complaints received by the local health department and the manner in which these complaints are presented. When residents present their concerns to public officials in a systematic fashion, they are presumed to be somewhat knowledgeable about the extent of the damage and its implications. The absence of an organized protest group does not necessarily imply ignorance and does not automatically disqualify a site from consideration. It does suggest, however, that more weight should be given to the other selection criteria.

Another indicator of widespread public concern with the hazardous waste site is association by residents of health impairments they experience with a hazardous waste site. Such health impairments may be documented by local health departments or other public agencies, or they may be undocumented and based on neighborhood consensus. While documented health effects are of major concern to residents, undocumented effects cannot be ignored.

Where there is ground water contamination, one additional potential indicator of public concern is the number of households who resort to using bottled water, as reported by the health department. The use of

---

[1]By the time PIE began Phase II, we were convinced that, given the large number of parameters, a larger real estate market was required. We used a population of 15,000 as the minimum.

bottled water as an alternative may be due to bad tasting water or "rotten egg" odors perceived by residents to be associated with the hazardous waste site.

Even if residents are concerned about a site, unless the concern persists long enough to be reflected in the real estate market it provides no basis for analysis of effects on property values. Two years are generally regarded as sufficient. However, this number will vary with population density and the velocity in the housing market. For initial site selection only minimal information on public concern is required (i.e., year that awareness began).

D. Control

In the absence of an ideal control area, a residential area that extends for at least two miles from the site is also a necessary characteristic in the choice of a study site. The gradient is used as a control for comparing the impact of the hazardous waste site on property values at different distances.

A site was selected for further investigation only if it met this first set of criteria.

E. Type of Contamination

There are esentially two major types of contamination. The first, which for a number of years has elicited widespread concern, is air pollution. This manifests itself in the form of noxious fumes and wind blown particles from fire and/or explosion. The second is water contamination.

Potential damages from hazardous waste include: ground and surface water contamination, air pollution and fire and explosion hazards. Since these hazards may affect property values differently, efforts were made to select a representative sample of the damages (scenarios).

The impact on property values of health threatening water contamination is likely to depend on the availability of alternative potable water supplies. Three alternatives are considered:

- o No municipal water is available to residents using contaminated water. This may occur when there is no municipal water nearby or the hookup costs are prohibitive. Residents may be able to drill wells to an uncontaminated aquifer, but again the cost may be prohibitive. (Additionally, deeper drilling of contaminated wells may not be allowed for fear of contaminating the underlying aquifer.)
- o Municipal water is available. The availability of municipal water is likely to dampen the impact of contamination on property values. This impact is likely to be further reduced if there is only a short lag between the discovery of contamination and attachment to municipal water.
- o Water contamination, while widespread, poses no threat to resident's potable water because all homes are attached to a safe supply of municipal drinking water. Hazardous waste sites in this situation might provide useful information on the non-drinking water effects of groundwater contamination.

F. Remedial Action

The degree and speed of remedial action will most likely influence residents' perception of the health hazards and may, therefore, affect the impacts on property values.[2] If clean up begins soon after the contamination is discovered and if clean up is expected to be thorough, the impact

on property values can be expected to be small. For example, existing home owners who would not consider selling their houses, were it not for contamination, might initially refrain from selling their homes because they anticipate rapid remedial actions. Larger property value impacts are to be expected when the clean-up is incomplete, long delayed or uncertain.

A hazardous waste site where remedial action was rapid and complete would, therefore, lack the after effect necessary for a study of this nature. Throughout our investigation in Phase I, we encountered no site with remedial action such as to warrant preclusion solely on that basis.

Owners might withhold real estate from the market if they suspect that remedial action will effectively increase land values above their pre-contamination levels. This could occur where extensive clean up removed other environmental disamenties that were previously depressing property values. In such a case the site was rejected since it was believed that meaningful evaluation of the changes between the pre- and post-contamination periods was not possible.

G. Industrial Interference

Nearby industrial plants, landfills, and other hazardous waste sites tend to share common, or possibly offsetting, characteristics with a study site, thereby making it diffficult to isolate their individual impacts on property values. These sites were not considered optimal for the purpose of this study.

---

[2]The options available to public officials range from immediate clean up (politically popular, but financially difficult) to superficial investigation (politically unpopular, but often financially necessary).

APPENDIX C: DETAILED RESULTS OF PHASE II

In this appendix, we present all the results of the runs carried out in Phase II. Table 1 presents the coefficients and related statistics. The variables are shown in the order in which they appear in the equations. Table 2 provides definitions and some comments on the variables.

Table 1

Coefficients and Their Associated F Statistics[1]

Independent Variables[3]	Runs[2] 1	2	3	4	5	6	7	8	9
Constant	2.836	1.187	4.394	3.011	0.106	0.147	2.852	2.789	3.002
LSZLN	0.093 (15.888)	0.119 (33.918)	- 0.074 (0.475)	0.053 (4.038)	0.052 (2.571)	- 0.012 (0.074)	0.111 (20.297)	0.090 (15.304)	0.098 (18.070)
AGE	- 0.002 (8.534)	- 0.002 (5.727)	- 0.005 (3.510)	- 0.002 (4.665)	- 0.000 (0.000)	0.001 (0.969)	- 0.002 (5.034)	- 0.002 (6.964)	- 0.002 (6.650)
COND	- 0.176 (22.482)	- 0.175 (25.865)	- 0.216 (2.648)	- 0.148 (13.172)	- 0.114 (4.835)	- 0.150 (2.323)	- 0.190 (23.737)	- 0.171 (21.645)	- 0.184 (24.540)
BMT	- 0.030 (3.774)	- 0.050 (11.781)	- 0.053 (1.231)	- 0.041 (5.166)	- 0.020 (0.595)	- 0.003 (0.007)	- 0.032 (4.317)	- 0.033 (4.428	- 0.033 (4.402)
AIR	- 0.046 (10.026)	- 0.048 (13.227)	- 0.019 (0.138)	- 0.052 (9.272)	- 0.057 (8.341)	- 0.071 (5.930)	- 0.046 (9.867)	- 0.045 (9.225)	- 0.045 (9.490)
GRGD	0.025 (0.089)	0.045 (0.447)	--	0.056 (0.328)	0.269 (6.153)	0.342 (7.614)	0.032 (0.135)	0.035 (0.170)	0.002 (0.001)

[1]Coefficients are not calculated for dummy variables for which the sample used has no observations. In addition, one dummy variable is omitted in each set, as shown by blanks in the Table.

[2]Dependent variable for each run was PVLN (defined on p. C-17).
Run 1 uses Model 1, enlarged sample (post-1974).
Run 2 uses Model 1, original sample (post-1974).
Run 3 uses Model 1, new sample (enlarged minus original sample, post-1974).
Run 4 uses Model 1, enlarged sample (post-1974).
Run 5 uses enlarged sample (pre-1974).
Run 6 uses original sample (pre-1974).
Run 7 uses Model 2, enlarged sample (post-1974).
Run 8 uses Model 3, enlarged sample (post-1974).
Run 9 uses Model 4, enlarged sample (post-1974).

[3]Independent variables are defined on pp. C-15 to C-18.

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
FPL	- 0.032 (3.825)	- 0.050 (10.165)	0.090 (3.512)	- 0.210 (1.26)	- 0.055 (5.139)	- 0.072 (2.806)	- 0.030 (5.003)	- 0.036 (5.106)	- 0.034 (4.41)
BTR	0.129 (67.021)	0.062 (14.185)	0.203 (19.716)	0.137 (57.534)	0.111 (17.938)	0.118 (7.179)	0.128 (66.654)	0.131 (69.175)	0.127 (64.87)
HRELN	0.101 (15.158)	0.278 (52.293)	0.007 (0.026)	0.116 (14.171)	0.281 (28.003)	0.255 (12.058)	0.107 (16.970)	0.106 (16.812)	0.104 (16.16)
GRGA	--	--	--	--	--	--	--	--	--
GRGB	0.061 (4.594)	0.072 (6.455)	0.009 (0.011)	0.092 (7.609)	0.081 (6.689)	0.151 (6.521)	0.058 (4.153)	0.063 (4.722)	0.056 (0.380)
GRGC	0.064 (4.514)	0.073 (6.135)	- 0.002 (0.001)	0.093 (6.919)	0.112 (9.708)	0.180 (7.455)	0.061 (4.015)	0.061 (4.014)	0.056 (3.49)
OTBN	0.044 (3.190)	0.051 (5.571)	0.076 (0.412)	0.053 (3.250)	0.058 (4.137)	0.048 (1.068)	0.041 (2.660)	0.043 (2.880)	0.043 2.951
DCBDLN	0.067 (1.586)	0.195 (5.184)	0.043 (.023)	0.066 (1.499)	0.006 (0.031)	0.004 (.039)	0.006 (0.014)	0.055 (2.087)	0.007 (0.022)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
DS1	- 0.163 (2.247)	- 0.179 (3.762)	--	- 0.123 (0.913)	--	--	- 0.157 (2.106)	- 0.148 1.807	- 0.188 (2.89)
DS2	0.002 (0.001)	0.002 (0.002)	- 0.241 (1.173)	--	0.031 (0.167)	0.026 (0.086)	- 0.034 (0.308)	- 0.009 (0.023)	- 0.025 (0.167)
DS3	0.140 (4.940)	--	0.348 (7.245)	--	- 0.042 (0.138)	--	0.113 (3.354)	0.147 (6.260)	0.142 (5.94)
DS4	--	--	--	--	0.026 (0.017)	--	--	--	--
DSD	- 0.003 (0.001)	--	- 0.418 (3.293)	--	--	--	0.097 (0.911)	0.078 (0.468)	0.025 (0.034)
DS5	- 0.136 (1.601)	0.273 (7.47)	- 0.282 (0.597)	--	- 0.089 (1.203)	- 0.114 (0.621)	0.106 (1.021)	0.118 1.240	0.103 (.942)
ZNB	- 0.046 (0.446)	- 0.46 (0.716)	--	0.071 (0.799)	0.211 (3.652)	0.383 (8.219)	- 0.021 (0.096)	- 0.021 (0.062)	- 0.077 (1.121)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
ZNF	- 0.137 (18.826)	- 0.062 (5.015)	--	- 0.141 (14.481)	- 0.037 (0.424)	- 0.049 (0.359)	- 0.073 (2.704)	- 0.132 (13.992)	- 0.121 (11.582)
ZNP	0.058 (1.250)	--	--	--	- 0.072 (1.359)	--	0.003 (0.398)	0.185 (0.169)	0.031 (0.463)
ZNQ	0.092 (1.075)	--	--	--	- 0.004 (0.001)	--	0.022 (0.089)	- 0.353 (0.002)	- 0.024 (0.097)
ZNA	- 0.005 (0.008)	0.003 (0.004)	0.782 (4.088)	0.029 (0.194)	--	--	0.000 (0.000)	0.008 (0.016)	- 0.026 (0.180)
ZNE	- 0.053 (6.665)	- 0.049 (5.607)	0.205 (0.909)	- 0.042 (3.256)	- 0.029 (0.827)	0.031 (0.318)	- 0.006 (0.049)	- 0.047 (3.699)	- 0.037 (2.054)
ZNJ	- 0.034 (0.413)	- 0.048 (0.798)	0.165 (0.195)	0.055 (0.561)	- 0.228 (5.657)	- 0.208 (3.800)	- 0.066 (1.284)	- 0.049 0.649	- 0.076 (1.645)
ZNO	--	--	--	--	- 0.097 (0.353)	- 0.230 (0.909)	--	--	--

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
PDEN	- 0.004 (0.006)	0.064 (.210)	0.239 (0.210)	- 0.014 (0.045)	- 0.073 (1.490)	0.039 (0.176)	- 0.042 (0.625)	- 0.069 (1.184)	0.053 (0.928)
CLE	- 0.490 (40.489)	- 0.386 (25.736)	- 0.885 (6.041)	- 0.479 (27.515)	- 0.310 (4.828)	- 0.765 (7.789)	- 0.492 (40.391)	- 0.482 (37.417)	- 0.505 (42.48)
CLF	- 0.370 (33.635)	- 0.281 (26.068)	- 0.563 (2.441)	- 0.363 (23.177)	0.066 (0.380)	- 0.472 (6.267)	- 0.379 (35.814)	- 0.370 (31.641)	- 0.378 (2.35)
CLG	- 0.098 (2.786)	- 0.055 (1.127)	- 0.149 (0.214)	- 0.169 (5.868)	0.037 (0.098)	- 0.203 (1.533)	- 0.105 (3.189)	- 0.087 (2.139)	- 0.091 (2.35)
CLH	--	--	--	--	--	--	--	--	--
PLG	0.148 (4.281)	0.202 (7.272)	0.087 (0.291)	0.162 (3.703)	- 0.021 (0.043)	- 0.072 (0.459)	0.158 (4.514)	0.176 (6.153)	1.70 (5.72)
PLV	0.140 (16.314)	0.135 (22.388)	0.426 (1.309)	0.147 (12.772)	- 0.020 (0.167)	- 0.025 (0.196)	0.145 (17.608)	0.146 (17.529)	0.153 (19.33)
DPWM	0.059 (3.101)	0.122 (10.334)	- 0.225 (2.609)	0.039 (1.122)	0.048 (0.816)	0.027 (.063)	0.027 (0.644)	0.049 (2.117)	0.044 (1.74)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
DACM	- 0.011 (0.081)	- 0.061 (1.720)	- 0.003 (0.000)	- 0.021 (0.217)	- 0.060 (2.012)	- 0.108 (1.075)	- 0.004 (0.023)	- 0.006 (0.037)	0.037 (0.794)
DD1	--	--	--	--	--	--	--	--	--
DD2	- 0.025 (0.593)	0.004 (0.019)	- 0.596 (1.865)	- 0.013 (0.112)	--	--	--	--	--
DD3	0.056 (2.098)	- 0.005 (0.029)	- 0.364 (2.322)	- 0.082 (3.212)	0.061 (3.764)	0.058 (2.317)	--	--	--
DD4	0.009 (0.044)	0.086 (5.131)	- 0.767 (5.242)	0.035 (0.527)	0.045 (1.347)	0.102 (1.337)	--	--	--
DD5	- 0.013 (0.076)	0.818 (3.533)	- 0.051 (0.077)	0.037 (0.005)	0.055 (1.521)	0.144 (1.442)	--	--	--
DD6	- 0.053 (0.707)	0.220 (2.448)	- 0.015 (0.009)	- 0.044 (0.438)	0.091 (2.052)	--	--	--	--
DD7	- 0.071 (1.219)	--	0.096 (0.429)	0.006 (0.007)	0.010 (3.898)	--	--	--	--

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
DD8	- 0.174 (2.248)	--	--	- 0.122 (1.018)	--	--	--	--	--
QD4/QDD4[4]	--	--	--	--	--	--	--	--	- 0.133 (1.91)
QD1/QDD1	--	--	--	--	--	--	--	0.022 (0.096)	- 0.065 (2.17)
QD2/QDD2	--	--	--	--	--	--	--	0.024 (0.096)	- 0.044 (3.10)
QD3/QDD3	--	--	--	--	--	--	--	0.054 (0.400)	- 0.028 (1.41)
SDA	0.481 (57.442)	0.504 (41.599)	0.679 (26.041)	0.493 (42.520)	--	--	0.510 (64.918)	0.499 (61.440)	0.498 (61.735)
SDA1	0.464 (16.434)	--	0.542 (5.520)	0.520 (14.758)	--	--	0.434 (13.851)	0.451 (15.818)	0.452 (15.934)
SDA2	0.482 (31.670)	--	0.689 (25.540)	0.471 (21.770)	--	--	0.469 (30.581)	0.483 (32.066)	0.485 (30.985)

[4]QD1-4 are used in Run 8. QDD1-4 are used in Run 9.

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
SDB	0.498 (92.212)	0.499 (78.409)	0.692 (22.259)	0.514 (69.768)	--	--	0.522 (103.514)	0.511 (96.702)	0.518 (98.882)
SDC	0.512 (78.066)	0.490 (59.522)	0.756 (10.853)	0.524 (57.775)	--	--	0.525 (83.414)	0.524 (83.054)	0.528 (84.387)
SDD	0.416 (49.164)	0.442 (46.326)	0.552 (15.924)	0.431 (37.667)	--	--	0.417 (49.612)	0.414 (50.073)	0.424 (52.096)
SDE	0.383 (52.878)	0.376 (43.326)	0.507 (8.187)	0.396 (40.117)	--	--	0.405 (60.433)	0.394 (56.870)	0.409 (59.823)
SDF	0.505 (83.678)	0.534 (83.388)	0.544 (10.449)	0.506 (59.284)	--	--	0.520 (89.761)	0.514 (87.715)	0.524 (83.388)
SDG	0.495 (77.831)	0.481 (68.714)	0.774 (9.580)	0.493 (54.798)	--	--	0.509 (83.289)	0.501 (80.440)	0.513 (83.292)
SDH	0.456 (40.112)	0.476 (44.747)	0.331 (2.235)	0.455 (28.485)	--	--	0.478 (44.258)	0.470 (42.685)	0.475 (43.632)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
SDI	0.469 (89.880)	0.435 (57.975)	0.658 (34.624)	0.472 (64.039)	--	--	0.490 (98.714)	0.478 (92.767)	0.486 (93.040)
SDJ	0.444 (98.654)	0.454 (69.177)	0.557 (38.768	0.443 (69.442)	--	--	0.462 (108.572)	0.450 (103.078	0.460 (105.938
SDK	0.315 (52.118)	0.329 (37.142)	0.359 (17.323)	0.276 (28.449)	--	--	0.328 (58.942)	0.325 (57.254)	0.331 (58.832)
SDL	0.259 (31.800)	0.290 (29.209)	0.301 (9.038)	0.267 (23.993)	--	--	0.267 (34.802)	0.268 (34.588)	0.274 (35.802)
SDM	0.255 (34.536)	0.271 (26.739)	0.274 (8.691)	0.245 (22.511)	--	--	0.260 (36.450)	0.263 (36.450)	0.269 (37.818)
SDN	0.212 (21.587)	0.227 (18.965)	0.376 (7.770)	0.214 (15.618)	--	--	0.223 (24.297)	0.223 (24.014)	0.227 (24.409)
SDO	0.201 (18.470)	0.197 (14.041)	0.355 (6.429)	0.206 (13.868)	--	--	0.207 (19.815)	0.210 (20.203)	0.217 (21.574)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
SDP	0.189 (12.491)	0.165 (7.636)	0.274 (5.103)	0.192 (9.098)	--	--	0.211 (15.788)	0.195 (13.430)	0.202 (14.455)
SDQ	0.157 (10.464)	0.174 (10.125)	0.199 (2.311)	0.158 (7.403)	--	--	0.168 (12.182)	0.167 (11.869)	0.172 (12.500)
SDR	0.141 (10.274)	0.140 (7.593)	0.245 (2.717)	0.144 (7.499)	--	--	0.151 (11.973)	0.148 (11.216)	0.152 (11.894)
SDS	0.131 (6.196)	0.145 (6.602)	0.012 (0.003)	0.135 (4.621)	--	--	0.147 (7.977)	0.143 (7.501)	0.149 (8.025)
SDT	0.062 (1.357)	0.080 (2.045	0.127 (0.289)	0.063 (1.007)	--	--	0.094 (3.180)	0.080 (2.276)	0.085 (2.586
SDU	0.110 (5.502)	0.128 (5.796)	0.136 (1.368)	0.118 (4.561)	--	--	0.130 (7.985)	0.124 (7.100)	0.128 (7.614)
SDV	0.084 (3.142)	0.079 (2.229)	0.184 (1.050)	0.076 (1.841)	--	--	0.095 (4.135)	0.095 (4.093)	0.101 (4.599)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
SDW	0.071 (1.957)	0.052 (0.850)	0.312 (5.735)	0.088 (2.088)	--	--	0.092 (3.308)	0.082 (2.601)	0.086 (2.920)
SDX	0.104 (3.428)	0.113 (3.368	0.193 (1.856)	0.128 (3.681)	--	--	0.115 (4.241)	0.119 (4.429)	0.125 (4.762)
SDY	0.050 (0.688)	- 0.018 (0.071)	0.152 (1.313)	0.047 (0.428)	--	--	0.068 (1.307)	0.053 (0.784)	0.063 (1.096)
SDZ	0.107 (2.951)	0.108 (2.455)	0.258 (3.297)	0.115 (2.434)	--	--	0.114 (3.406)	0.119 (3.685)	0.122 (3.875)
SDAA	0.089 (2.200)	0.164 (6.985)	- 0.022 (0.016)	0.098 (1.904)	--	--	0.103 (2.975)	0.098 (2.677)	0.106 (3.124)
SDBB	0.034 (0.222)	0.058 (0.595)	0.214 (1.537)	0.018 (0.044)	--	--	0.043 (0.358)	0.043 (0.361)	0.051 (0.519)
SDCC	0.082 (2.269)	- 0.068 (1.356)	0.174 (1.536)	- 0.001 (0.000)	--	--	0.095 (3.108)	0.091 (2.828)	0.097 (3.226)

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
SDDD	- 0.020 (0.135)	- 0.002 (0.001	0.130 (1.223)	- 0.040 (0.427)	--	--	- 0.012 (0.053)	- 0.011 (0.044)	- 0.004 (0.005)
SDEE	0.038 (0.595)	0.042 (0.591)	0.128 (1.228)	0.028 (0.229)	--	--	0.057 (1.388)	0.052 (1.166)	0.062 (1.625)
SDFF	--	--	--	--	--	--	--	--	--
SDTRND[5]	--	--	--	--	0.915 (265.864)	1.034 (200.752)	--	--	--
WKN	--	--	--	--	--	--	- 0.104 (5.030)	--	--
WSW74	--	--	--	--	--	--	- 0.031 (0.389)	--	--

[5]A sales trend was computed for sample 2 only in Phase II because of time and budgetary constraints. The sales trend is simply an aggregation of the coefficients of individual dummy variables computed in an earlier run, and, therefore, equivalent to the series of individual dummmy variables.

Table 1 (continued)

Coefficients and Their Associated F Statistics

Independent Variables	Runs 1	2	3	4	5	6	7	8	9
WDLB76	--	--	--	--	--	--	- 0.037 (0.087)	--	--
WDLA76	--	--	--	--	--	--	- 0.124 (3.281)	--	--
WM	--	--	--	--	--	--	- 0.020 (0.382)	--	--
M75Z1	--	--	--	--	--	--	0.074 (1.935)	--	--
WW	--	--	--	--	--	--	--	--	--
Summary Statistics									
$\overline{R}^2$	0.851	0.905	0.844	0.793	0.811	0.815	0.852	0.849	0.850
F	43.564	57.812	8.475	32.356	38.948	25.263	44.618	45.683	45.281
Sample Size	630	460	170	630	383	216	630	630	630

Table 2

Definitions of Variables and Comments

CODE	VARIABLE	DESCRIPTION/COMMENTS
AIR[1]	air conditioning	yes = 0, no = 1
AGE	age of house when sold	year built-sales date
BMT	basement	yes = 0, no = 1
BTR	bathroom	number of bathrooms
COND	condition	good (G) = 1, fair (F) = 2, poor (P) = 3
CLE[1]	classification for below average construction	yes = 1, no = 0
CLF[1]	classification for average construction	yes = 1, no = 0
CLG[1]	classification for above average construction	yes = 1, no = 0
CLH[1]	classification for good grade size and construction	yes = 1, no = 0
DACM	distance to highway access	distance measured in miles
DD1 to DD8[1]	distance from the waste dump in .5 mile dummies	DD1 = first 1/2 mile[2] DD2 = second 1/2 mile, etc.
DS1,2,3,4,5,D[3]	distance to schools	within 1/4 mile = .25 between 1/4 and 1/2 mile = .5 over 1/2 mile = 1
DPWM	distance to highway	distance measured in miles

Table 2 (continued)

Definitions of Variables and Comments

CODE	VARIABLE	DESCRIPTION/COMMENTS
DCBD	distance from central business district	
DCBDLN	natural log of DCBD + distance to central business district	distance measured in miles
FPL[1]	fireplace	yes = 0, no = 1
GRGA[1]	no garage	yes = 1, no = 0
GRGB[1]	1 car garage	yes = 1, no = 0
GRGC[1]	2 car garage	yes = 1, no = 0
GRCD[1]	3 car garage	yes = 1, no = 0
HRELN[4]	natural log of HARE = total floor area	measured in square feet
LSZLN[4]	natural log of LSZ = lot size	frontage x dept, additional acres are added Total converted to square feet (1,000 ft^2)
OTBN	number of outbuildings	
PLG[1]	in-ground pool	yes = 1, no pool = 0
PLV[1]	vinyl pool	yes = 1, no pool = 0
PDEN	average number of rooms per person in enumeration district	
PVLN	natural log of PV = property values	sales price in $1,000

Table 2 (continued)

Definitions of Variables and Comments

CODE	VARIABLE	DESCRIPTION/COMMENTS
QD1-4	directional dummies	QD1 Northeast quadrant Yes = 1 No = 0 QD2 Southeast quadrant Yes = 1 No = 0 QD3 Southwest quadrant Yes = 1 No = 0 QD4 Northwest quadrant Yes = 1 No = 0
QDD1-4	directional distance variables (continuous)	QDD1 = distance from waste dump, miles if QD1 = 1 QDD2 = distance from waste dump, miles if QD2 = 1 QDD3 = distance from waste dump, miles if QD3 = 1 QDD4 = distance from waste dump, miles if QD4 = 1
SDFF to SDA2 (1974-1982)	sales dummies	time trended according to quarter and year beginning with second quarter 1982. SDA2; series runs SDA2 SDA, SDB...SDZ, SDAA, SDBB...SDFF, which is the first quarter of 1974
SDTRND	sales dummies trend for sample 2	SDFF $= \sum_{i = A2} SD_i \times \text{coefficient } SD_i$
WKN	No information	Yes = 1 No = 0
WW	Wells determined not to be contaminated	Yes = 1 No = 0
WM	Municipal Water only	Yes = 1 No = 0

Table 2 (continued)

Definitions of Variables and Comments

CODE	VARIABLE	DESCRIPTION/COMMENTS		
WSW74	Wells contamined in 1974 which switched to municipal water	Yes = 1	No = 0	
M75Z1	Built in 1975 in contamination Zone 1	Yes = 1	No = 0	
WDLB76	Wells in Dugan's Lane area before 1976	Yes = 1	No = 0	
WDLA76	Wells in Dugan's Lane area after 1976 contamination	Yes = 1	No = 0	
ZNA[1] to ZNF and ZNJ to ZNQ	Zoning[4]			
	ZNA = Residential, Rural	Yes = 1	No = 0	
	ZNB = Rural Highway Business (Commercial)	Yes = 1	No = 0	
	ZNE = Residential R-150	Yes = 1	No = 0	
	ZNF = Residential, Planned Retirement Community	Yes = 1	No = 0	
	ZNJ = Residential R-400	Yes = 1	No = 0	
	ZNO = Residential R-200	Yes = 1	No = 0	
	ZNP = Residential R-90	Yes = 1	No = 0	
	ZNQ = Residential R-50	Yes = 1	No = 0	

[1]Dummy variables.

[2]DD1 and, in some cases, DD2 were the ommitted variables in the group.

[3]DSD is the same as 4 except that it is adjusted to account for residences sold before the school was built. This adjustment only had to be made in the pre-1974 sample.

[4]See "Further Comments," Appendix C, Volume I, for a full description.

APPENDIX D: COMMENTS OF REVIEWERS

In this appendix, some of the comments made on Phase I of the study by eight reviewers are presented and addressed.[1] Reviewers were asked both to criticize the existing text and to comment on whether the study warranted further analysis and, if so, to suggest new approaches. Some of the reviewers not only suggested new approaches, but also commented extensively on the approach adopted in Phase I. Ideally, some of these suggestions would have been addressed and incorporated into the main body of Volume I, however, time and budget constraints did not permit doing so. Also, by the time the comments were received, Phase II had been virtually completed so it was not possible to incorporate all the suggestions even into the latter Phase. However, most of the important criticisms and comments had already been taken into account in performing Phase II of the study. Discussions among the project staff, comments from EPA staff and informal conversations with outside students of environmental economics, including some of the reviewers, had brought forward many of the criticisms that appeared in the formal reviews.

In this appendix, we present and discuss the major comments and suggestions provided by the reviewers, particularly those that were not completely covered in the text of this report.

---

[1]The reviewers are A. Myrick Freeman, III, Department of Economics, Bowdoin College; Robert M. Schwab, Department of Economics, University of Maryland; Jon D. Harford, formerly on the Benefits Staff, Office of Policy Analysis, U.S. Environmental Protection Agency; Robert Mendelsohn, Department of Economics, University of Washington, Seattle, Washington; Allen V. Kneese, Resources for the Future, Washington, D.C.; V. Kerry Smith, Department of Economics, Vanderbilt University; Steve Beggs, Charles River Associates, Boston, Massachusetts; and Al McGartland, Benefits Staff, Office of Policy Analysis, U.S. Environmental Protection Agency.

The comments dealt with the theory and its application and both general and specific technical changes in the computational methodology. The reviewers made no suggestions for obtaining major new sets of data other than those that had already been incorporated in Phase II.

Before discussing the particular suggestions, it is appropriate to mention that several reviewers raised questions about homogeneity of tastes and income among the buyers and sellers in Pleasant Plains. We believe that problems of heterogeneity in these parameters are adequately controlled by virtue of the fact that the Pleasant Plains area is a relatively small part of a larger real estate market. Overall, the reviewers did not present arguments which would justify work beyond Phase II.

Suggestion 1: Very recent housing price data should be isolated to investigate the persistence over time of any impact of proximity to a hazardous waste site on house prices.

The purpose of such an examination would be to determine, first, whether and, if so, when the effect of information about a hazardous waste site became stale and prices settled at a new equilibrium, or, alternatively, whether awareness of the risks was long delayed or had a cumulative effect over time, contributing to a lag in realizing and stabilizing downward pressures on prices.[2] The consequences of a finding

---

[2]Hedonic equations can be the basis of benefit calculations only if it can be assumed that the housing market was in stock equilibrium in the time period for which the equation was estimated. However, with rational expectations, the market is always in equilibrium, given existing information. Hence, there is only a problem of information. If participants in the real estate market are not adequately informed, property prices will understate (if such risk is exaggerated, overstate) costs of the dump.

that prices do not stabilize until long after local residents had apparently become aware of the incident would suggest that the threshold date chosen to reflect the onset of public awareness was inappropriate and unlikely to generate reliable empirical results.

An investigation of this question was undertaken indirectly in Phase I. The sales-date dummy variables associated with a sample of transactions inside the contamination zones and a sample of the transactions outside the zones were compared to determine whether the rate of increase in house prices was the same in both samples. (The latter sample was to act as a control.) If the actual price impacts were greater inside than outside the contaminated zone, one might expect prices to rise more slowly, at some stage, inside the zone than outside it, before some long-run equilibrium were reached. The analysis shows no indication of such a differential. Indeed, prices generally seemed to rise faster inside the contaminated zones than outside. Unfortunately, a more direct investigation of the question, e.g., generating and testing subsamples of observations by year or by groups of years, is not feasible, because the samples would be too small without a significant simplification of the model.

Another suggested approach was to introduce distance and time as an interactive variable. This would demonstrate whether prices as a function of distance were rising at an accelerating rate. Finally, it was suggested that an interrupted time series approach might be used on the whole sample to determine whether and, if so, when there was a distinguishable interruption in the response of property values to the incident. Neither of these approaches have been applied, largely because of lack of time and

resources but also, in the case of the first, because with the failure to develop any trend associated with distance, there appeared little point in modifying the distance variable with a time subscript.

Suggestion 2: Not to use homogeneity of incomes as a criterion for site selection and consequently consider a larger number of sites as candidates for empirical research.

Heterogeneity of taste or incomes across households does not impair the validity of the results, if the model is used in one affected community which is a small part of a much larger urban housing market and if the sample is large enough to capture the behavior of the entire market. Consequently, a larger number of communities would be or could be considered as candidates.

In practice, no communities were rejected as subjects of empirical research because of not being sufficiently homogeneous.

Suggestion 3: Examine whether the adverse effects of the hazardous waste sites is more closely associated with other factors than with the proxy variables. If that were true, the proxy variables would not constitute reliable indicators of the effects of the site.

We judged that the sales-date dummy variables were most likely to capture some of the effects generated by the hazardous waste site as a consequence of the fact that there might be different impacts on house prices over time. On examination, this did not seem to have occurred. Another variable which might have been affected by the disamenity is lot size. This was not examined. Obviously there is an essentially unlimited list of variables that might have been important. In light of the fact that the models actually used proved to be good predictors of

property values, it appeared that there would be little value in introducing additional variables unless there was some analytic basis for assuming that they were correlated with distance or contamination.

Suggestion 4: Examine in more detail the nature of the risk associated with proximity to the hazardous waste site for individual residences; how that risk is associated with a particular site attribute, such as water contamination; how individual households are made aware of the nature of such risk, and whether they are likely to understand the specific implications it has for their residential location.

In Phase II, additional consideration was given to the first two questions. It was recognized, for instance, that physical factors such as underground drainage and gradient were important in affecting the geographic distribution of exposure to the risks posed by water contamination. For this reason, prices were examined with respect to direction from the site, as well as distance. Further, because, to our knowledge, actual exposure to health risks was limited to those who used wells, more attempts were made in Phase II to isolate the individual households that used them.

Water contamination was the only site attribute that we judged to be likely to create a tangible disamenity in Pleasant Plains. The disamenity included health risks, any subsequent inconveniences experienced as a result of having to switch to a municipal water supply with the loss of "preferred" private wells. We know of no evidence that surface water contamination around the site was a problem. In addition, since there was no odor and the drums containing the chemicals were not visible from the perimeter of the property, aesthetic considerations were unlikely to be important. No evidence of air pollution was identified.

With respect to the two comments concerning residents' awareness: Although it might have been possible to glean more information from news coverage at that time, without (and perhaps with) a survey it would be impossible to acertain the nature of individuals' perception of the risk. Documentation on the incident provides the only information for this study on the two questions of actual exposure and risk and perceived exposure and risk.

Suggestion 5: The method used to select independent variables, which involved maximizing the $\overline{R}^2$, is inappropriate.

Contrary to the interpretation of some reviewers, the purpose of maximizing the $\overline{R}^2$ was not primarily to maximize the goodness of fit. The technique was not used on the proxy variables; but it was used to deal with the problem of multicolinearity among the property characteristic variables. Selecting variables according to the criteria of maximizing the $\overline{R}^2$ is a widely accepted procedure (albeit not the only one) in such circumstances.

Suggestion 6: Amend the hedonic property model to deal with decision making in the presence of uncertainty.

The theoretical points associated with the issue of uncertainty have not been addressed in this or in other studies applying the hedonic models to evaluating disamenities. They constitute an important area for future work.

Uncertainty in decision making exists in situations where the magnitude of risks is not known or fully understood by the decision makers. While a determination was made of likely exposure of residents to hazardous substances in Pleasant Plains soon after the incident and the results of this determination were well published, there remained some uncertainty about the actual exposure of individual residents to these substances.

Further, knowledge of risk, by its nature, does not provide certainty. In addition, any real estate transaction is replete with uncertainty, since the present value of property is always a reflection of estimates of the effects of future developments in the market. The Pleasant Plains case, however, appears to be an example of a situation in which the area of uncertainty was reduced substantially soon after the incident and remained stable subsequently. Within the first few months of the incident, the contamination zones were defined and actions were taken to reduce the associated risks. While there was a new discovery of contamination in 1976, it was within the known area at risk, i.e., within the existing contamination zone. This suggests that uncertainty was not an important factor in decision making in the Pleasant Plains case.

Suggestion 7: Functional forms, in addition to the ones used in this study should be introduced, particularly for variables for which the semi-log specification may not be appropriate, e.g., some of the contamination, locational, and some property characteristic variables. Another suggestion was made concerning the specification of the dependant variable, i.e, that it should be expressed as price per square foot of house or lot. This is a technique used to deal with a potential problem of heteroskedasticity, i.e., where the variance of the error term is greater for larger lots or houses than for smaller ones.

While several functional forms for the contamination variables were tested in Phase I, only one, the semi-log transformation, was used for these variables in Phase II. While testing different functional forms for the relevant contamination variables may be a useful area for further research, it is unlikely to change the results substantially. The dummy

variables representing distance (the only ones which permit investigation of alternative functional forms) have the "wrong" signs in this study, as well as being statistically insignificant.

Modifications of some of the more important variables other than the contamination variable were undertaken in Phase II, i.e., for lot size and house size; however, this was not done for other non-contamination variables. Of these other variables the specification of the locational variable may be of particular importance since there is some interaction between these and the relevant contamination variable. Distance from the highway is an example of a locational variable for which the semi-log specification may not be appropriate (prices are expected to rise at an increasing rate away from the highway, according to this specification). Further work is recommended in this area.

Another change in specification that it might be worthwhile to test is the conversion of property prices into price per square foot. Currently both lot size and house size are entered as independent variables; using price per square foot, instead, would result in dropping one of these variables from the right hand side of the equation and expressing it on the left. This procedure might be undertaken for both variables in separate runs, but not concurrently. Thus, it might be impossible to remove all potential heteroskedasticity. However, since the largest lots (lots more than two acres) were removed from the sample, any potential heteroskedasticity problem (with respect to lot size) is unlikely to be severe.

Suggestion 8: Either omit the date of sale or specify it as a continuous variable, instead of as a quarterly dummy variable. It could

be omitted if sales price were expressed in constant dollars. Alternatively, if it were expressed as a continuous variable, it might be appropriate to express it as a high degree polynomial. In either case, the degrees of freedom available would be increased substantially.

While either of these two suggestions would increase the degrees of freedom available, neither would capture the nature of the non-linearity as well as do the quarterly dummies. In fact, a major reason for using the quarterly dummies was to examine the nature of any non-linearity associated with sales prices over time, since there is no way of predicting such non-linearity a priori. In Phase I, having established this pattern, we introduced into some of the regressions a single trend variable which incorporated the information observed through using the sales dummies. The purpose of doing so was to simplify the equation for the purpose of exposition. Although technically this also increases the degrees of freedom available, it does not provide any new information. (The coefficients on the other variables do not change, only the f and t ratios and the associated $\overline{R}^2$ improve).

Suggestion 9: Use dummy variables to represent individual neighborhoods (blocks, developments, etc.) instead of the locational variables used (distance from schools, highways, etc.).

It is argued that this approach would avoid the likelihood of substantial specification errors and that the locational variables we used serve as poor proxies for more important neighborhood characteristics.

While there is evidence to support the notion that some of the distance variables are misspecified (the school variables, for example, have different signs and some are statistically insignificant), creating

plausible neighborhood dummies would involve extensive discussion with local realtors. This might be a worthwhile but costly endeavor.

In addition, further examination of the contamination zone dummies might reveal that some are acting as neighborhood dummies. This question would need to be investigated before separate (additional) neighborhood dummies were introduced. It is probably unnecessary to account for the smallest neighborhood units (blocks, developments, etc.) in a time-series analysis, since the characteristics differentiating them are unlikely to change substantially over a few years. However, some investigation of this issue would have to be made.

Suggestion 10: Select and test a sample of repeat sales (instances where particular properties are represented in the sample by more than one sale).

Where repeat sales data are identified, the estimation of the complete hedonic equation could be broken down into a two-stage procedure, in the first stage price changes would be explained by the relative changes in the environmental variables (as well as relative changes in depreciation and any other observed variables that are specified to change over time). The full hedonic equation could be estimated in stage 2, using the complete sample of single sales as well as repeat sales and imposing the coefficients on the environmental variables estimated in stage 1. The second stage is desirable, but not essential to such a modification of the study, as it is the coefficients of the environmental variable that are of major interest in this study (and they would be estimated in the first stage).

An advantage of identifying and testing such a sample is that it permits the use of a simpler model; only attributes which change over

time need be included. House lot characteristics, property specific and neighborhood variables that remain constant over time for each property need not be included.

While this may be a reasonable assumption for some characteristics, it is not plausible for all of them. Many of the residences in the area, for example, were improved or expanded during the period of study. Accounting for all such changes would be feasible but difficult.

A principal advantage of this method is that it eliminates the need to include the locational variables. These, as indicated previously, may be misspecified. However, the method does not eliminate the need to include some sort of overall neighborhood variable since it is clear that the entire area has become more desirable. A suggestion was made to introduce a development variable, such as density, into a time series analysis of the kind described above. The "neighborhood" variable would reflect the fact that Pleasant Plains as a whole had undergone development during the period of study.

Obviously the great disadvantage of using repeat sales is that they constitute only a small sample of total transactions. The question of whether the consequent reduction in degrees of freedom would be more than or less than offset by the reduction in degrees of freedom required has not been examined in detail. Our casual impression is that the limitation on sample size would prove unduly restrictive.